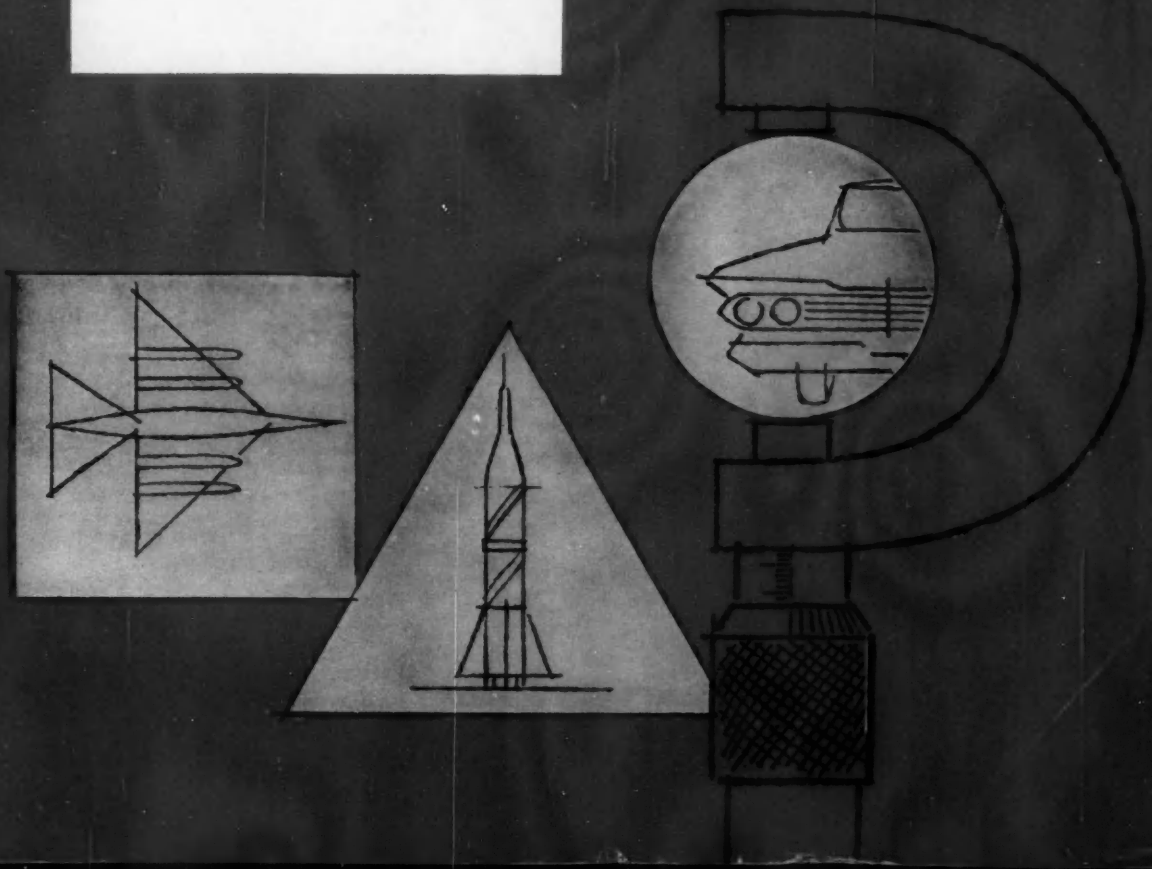
Published by THE SOCIETY OF AUTOMOTIVE ENGINEERS

NOVEMBER 1961

JOURNAL

1962 passenger-car engineering trends 30
Oil additives can aid equipment designer 49
Europe's small aircooled engines today 52
How to limit truck drive train vibration 58
Aircraft designers — what's weight worth? ... 60



PERFECT CIRCLE PISTON RINGS ARE INSTALLED AS ORIGINAL FACTORY EQUIPMENT IN 95 BRANDS OF VEHICLES AND ENGINES

WHY THE "PROS" PREFER PERFECT CIRCLE PISTON RINGS:

PC IS FIRST IN PRECISION

Perfect Circle's specially-designed grinding, milling and finishing equipment results in piston rings that are precision-made to millionths of an inch.

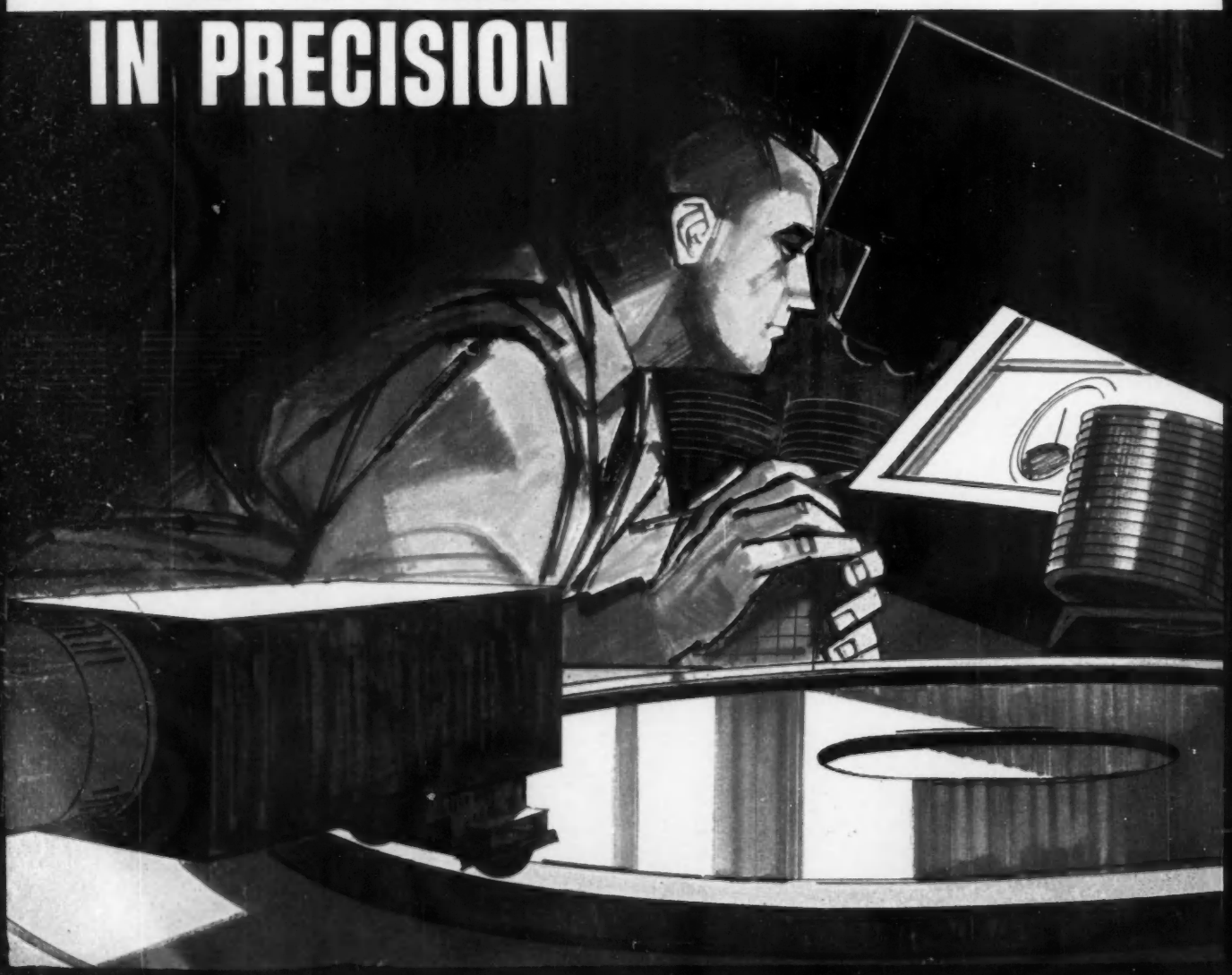
To inspect the finished rings, PC uses a profilometer—a highly-sensitive instrument that detects microscopic variations in surface smoothness. As the ring rotates on a turntable, it is tracked by the profilometer sensing arm which moves in and out to give a two-dimensional measurement.

Precision manufacturing, controlled by continuous inspection, makes PC rings fit better and last longer. It's another reason why they're preferred by so many leading engine and vehicle manufacturers throughout the world.

For superior precision that pays off in superior performance, contact your Perfect Circle representative.

PERFECT CIRCLE

PISTON RINGS • PRECISION CASTINGS • SPEEDOSTAT • ELECTRONIC PROGRAMING EQUIPMENT
Hagerstown, Indiana • Don Mills, Ontario, Canada



JOURNAL

Society of Automotive Engineers

PUBLICATION DIVISION

manager and editor, David L. Staiger

SAE JOURNAL

editor, Norman G. Shidle
associate editor, David L. Staiger
managing editor, Eleanor D. Allen
technical editor, Otto W. Vathke
technical editor, Saul J. Laskin
engineering editor, Walter G. Patton
production, Mary Grillon

OFFICERS OF SAE

president, A. A. Kucher
treasurer, G. A. Delaney
sec. & gen. mgr., Joseph Gilbert

SAE PUBLICATION COMMITTEE

chairman, Leonard Raymond
M. G. Beard
R. S. Frank
T. L. Swansen
W. Paul Eddy
A. O. Willey

Publication Office
10 McGovern Ave., Lancaster, Pa.

Society Headquarters
Editorial and Advertising Office
485 Lexington Ave., New York 17, N. Y.
Tel: OXford 7-3340; Teletype: NY1 228

Detroit Branch manager, G. J. Gaudaen
635 New Center Bldg., Detroit 2, Mich.
Tel: TRinity 1-1772; Teletype: DE 826

Western Branch manager, E. W. Rentz, Jr.
714 W. Olympic Blvd., Los Angeles 15, Calif.
Tel: Richmond 9-6559

ADVERTISING OFFICES

advertising manager, Edward D. Boyer
Pennsylvania, New York, and East
485 Lexington Ave., New York 17, N. Y.

Fred Wilks
Eastern Michigan and Eastern Ohio
635 New Center Bldg., Detroit 2, Mich.

W. W. Milne
Midwest and Western Ohio
7530 Sheridan Rd., Chicago 26, Ill.

Pacific Coast Reps., Chris Dunkle & Assocs.
740 S. Western Ave., Los Angeles 5, Calif.

European Rep., Brayton Nichols
7 Blenheim St., London W.1, England

Contents • November, 1961

INDEX of 1961 SAE Journal technical articles will appear in the December 1961 issue

Chips . . . from SAE meetings, members, and committees 29

1962 passenger-car engineering trends 30

The phenomenal success of the small car is leading to many engineering changes in the automobile industry. It has brought increased emphasis on weight reduction on both small and full-size cars. Improving reliability and designing to eliminate grease fittings have also become important objectives. — **Walter G. Patton**

Oil additives can aid equipment designer 49

Additives properly incorporated in mineral oils allow the equipment designer to do things that otherwise would be impossible. Additives alter the performance properties of oils much as alloys vary the properties of metals. They make it possible to go to higher temperatures, higher output, and lower cost design. (Paper No. 397A) — **L. W. Manley and N. V. Messina**

Europe's small aircooled engines today 52

Small gasoline engine development in Western Europe since 1957 takes the form of refinements to meet changing market conditions. Diesel advances, however, are tending to relegate gasoline engines to lower-power, light-duty applications — with the heavy-duty field (4–5 hp and up) tending to become the domain of the diesel. (Paper No. 394A) — **W. E. Meyer**

Geared torque converters give better performance 55

Broad ratio coverage and high efficiency, not possible in a pure hydrodynamic torque converter, can be attained by incorporating mechanical gear trains with the converter. With such a system the smooth torque characteristics of the pure hydraulic converter can be retained. (Paper No. 359C) — **F. H. Walker**

How to limit truck drive train vibration 58

There is increasing awareness that drive train noise and vibration in trucks need to be reduced for the sake of the man in the cab. To be eliminated is a great spectrum of vibration that will not harm the truck, but which will annoy, distract, fatigue, or even injure the man. The various aspects of the problem include: universal joint vibration, propeller shaft critical speed, and engine mounts. (Paper No. 402A) — **Michael C. Kaye**

Aircraft designers — what's weight worth? 60

Recognize the breakeven point, where weight reduction does not pay . . . and stick to it. (Paper No. 421A) — **W. A. Heacock.**

Computers help design turbine engine control 62

A gas turbine engine control can be designed even before the engine is available, and "debugged" without actually building the control. All this is possible by using analog computers which can simulate both the engine and the control. (Paper No. 398A) — **V. L. Larrowe and M. M. Spencer**

British view materials for supersonic transport 64

British engineers are investigating materials for aircraft structures operating at temperatures up to 700 F. This is one part of a design study of the supersonic transport and aircraft in the Mach 2.0–3.0 range. (Paper No. 420A) — **P. F. Kiddle and P. J. McKenzie.**

To order papers on which articles are based, see p. 6.

Continued on page 2

Contents • November, 1961 • Continued

Engine oil analysis is sound maintenance tool 66

Oil analysis provides an inspection technique to develop lower maintenance costs as well as a reporting system indicating fleet condition and cost trends. It is independent of errors associated with the cost reporting responsibilities of line supervisors. It is impartial; it bases on factual experience, and its cost runs 50¢, per vehicle per month. (Paper No. 406A) — **Capt. R. S. Stewart**

Twin Disc power shift transmission is flexible 68

This transmission combines the flexibility of the torque converter with the economy and performance of the direct geared transmission, according to its builders. (Paper No. 412A) — **J. B. Snoy**

Pick a powerplant for a Mach 3 transport 75

Three basic considerations involved in choosing a powerplant for a Mach 3.0 commercial transport: thrust flexibility in meeting aircraft requirements between take-off, climb and acceleration, and subsonic and supersonic cruise; special performance considerations, such as inlet compatibility and engine component efficiencies; and life and reliability in the severe operating environment at Mach 3.0. (Paper No. 427B) — **R. C. Hawkins**

Trim drag helps mold supersonic transport's shape 78

The trade between subsonic stability and supersonic trim drag is one of the fundamental design considerations in a supersonic cruise airplane, and poses a very serious problem. All supersonic airplanes have additional drag associated with trimming out unbalanced moments. Minimizing this drag through different configuration approaches is possible. (Paper No. 423D) — **R. B. Brown**

Detonative combustion applied to hypersonic ramjets .. 80

Conventional ramjets designed for hypersonic flight encounter many problems which could be alleviated by using detonative combustion. In this case, flame speeds are high (several orders of magnitude higher than the ordinary velocity of propagation), and inlet velocities can be correspondingly high. This means that combustible mixtures can be burned at supersonic speeds in a ramjet combustion chamber instead of first having to be diffused to subsonic speed. (Paper No. 419A) — **M. Arens**

One engine out — but all props turn 82

New Breguet 941 STOL aircraft, flown for the first time at the recent Paris Air Show, employs an unconventional propeller system for better control and safety. (Paper No. 428A) — **Georges Ricard, Joseph Czinczenheim, P. E. Jaillard and Guy de Richemont**

"Duplex" tire designed to replace duals 84

The "Duplex" tire is a single tire capable of carrying the load of duals, yet little larger in diameter. The new tire saves weight, approaches duals in mileage, and makes possible better design of vehicles. (Paper No. 415B) — **Ray Kupp and E. B. (Bert) Ogden**

2 new fuel controls for industrial gas turbines 86

The type of fuel control needed on a gas turbine depends on the particular gas turbine it is to be applied to. For instance, a low compression ratio gas turbine that is to be used at a single fixed speed can use a simpler, less costly fuel control than can a variable-speed turbine operating at high compression ratio. Both these types are discussed here. (Paper No. 398E) — **F. W. Newburgh and Bruce Ingold**

More on page 1

To order papers on which articles are based, see p. 6.

Heat treat developments match other metal advances 90
Impact of numerical control goes beyond cost savings 90
Data processing aids warehouse operations. 90
Companies turn to computers for requirements, scheduling, and forecasting 91
Spectrographic control in motor truck maintenance 91
Preignition-causing deposits are different . 92
Deposit-tendency index developed for jet fuels 92
Fuels, oils ready for 12/1 CR engines 92
Long life for alternators 93
Extended expansion brings fuel savings ... 94
3 areas pose potential trouble spots for plastics 94
Digital computer evaluates tractor-scraper performance 95
Unit exchange plan benefits engineering . 95
707 tests on wet runway show ribbed tires are best 96
Capillary-flow meters good to measure engine airflow 96
Dipping primers resist unitized-body corrosion 96
Fuel-cell-powered vehicle can have high performance 97
Diesel not yet threatened by turbine 97
Nitric oxide in trace amounts can affect engine knock behavior 98
Compound design benefits with aluminum engine use 98
Farm machine design on eve of great advance 129
Retarder capacity varies with system 129
Canard ducted-prop VTOL rates best in Douglas study 130
Aluminum makes good in off-highway bodies 133

Briefs 5
Editorial 27
News ..... (Contents) 99
New SAE Reports 105

READERSHIP Eastman RESEARCH

BPA

The Society is not responsible for statements or opinions advanced in papers or discussions at its meetings or in articles in SAE Journal.

A complete index of all Journal technical articles, from January through December, will appear in the December issue. All Journal technical articles are indexed by Engineering Index, Inc. SAE Journal is available on microfilm from University Microfilms, Ann Arbor, Mich.

Copyright 1961, Society of Automotive Engineers, Inc.

SAE JOURNAL, November, 1961, Vol. 69, No. 11. Published monthly except two issues in January by the Society of Automotive Engineers, Inc. Publication office at 10 McGovern Ave., Lancaster, Pa. Editorial and advertising department at the headquarters of the Society, 485 Lexington Ave., New York 17, N. Y. $1 per number; $12 per year; foreign $14 per year; to members 50¢ per number, $5 per year. Entered as second class matter, Sept. 15, 1948, at the Post Office at Lancaster, Pa., under the Act of Aug. 24, 1912. Acceptance for mailing at special rate of postage provided for in the Act of Feb. 28, 1925, embodied in paragraph (d-2), Sec. 34.40, P. L. and R., of 1918. Additional entry at New York, N. Y. Second class postage paid at Lancaster, Pa. and additional office N. Y. C.

NEW BORG & BECK 12-INCH CLUTCH FITS INTO 11-INCH BELL HOUSING

Packs More Muscle for School Buses, Medium-Duty Trucks, Diesel Conversions

Now—for the first time—you can get greater load capacity in school bus and truck clutches, without changing flywheel size, housing, motor mounts or pedal linkage.

This new Borg & Beck 12A5 clutch mounts on the same flywheel bolt circle, in the same size housing, as B&B Type 11A8—yet provides substantially more load capacity. And that means longer life, more engagements, more miles of on-the-go service under punishing stop-and-go operation.

Already adopted as original equipment by two leading school bus and truck makers, Type 12A5 is also the answer for stepped-up capacity in replacement service. And it's recommended, too, for conversions from gasoline to diesel operation.

Like all Borg & Beck clutches, the new Type 12A5 is designed, engineered and built to B&B's leadership standards for quality, performance and value. That's your dependable assurance of complete satisfaction.

BORG & BECK CLUTCH · THE STANDARD ·

Reg. U.S. Pat. Off.

BORG & BECK
B-W
DIVISION
BORG-WARNER

BORG & BECK®

THE AUTOMOTIVE STANDARD FOR NEARLY 50 YEARS

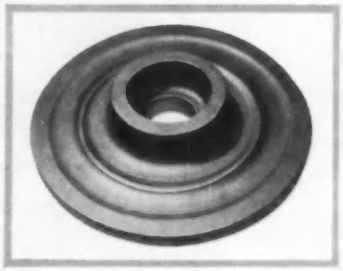
BORG & BECK DIVISION, BORG-WARNER CORPORATION, CHICAGO 38, ILLINOIS

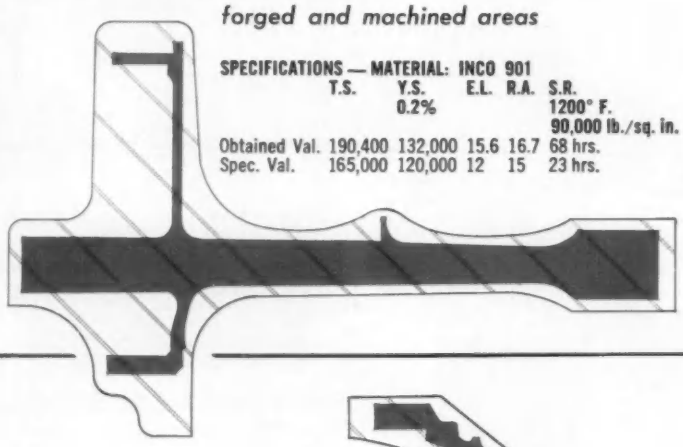
Export Sales: Borg-Warner International, 36 S. Wabash, Chicago 3

NEW HIGHS

IN METALLURGICAL PROPERTIES FROM EXOTIC METALS*

DISC TURBINE WHEEL and half cross section showing forged and machined areas

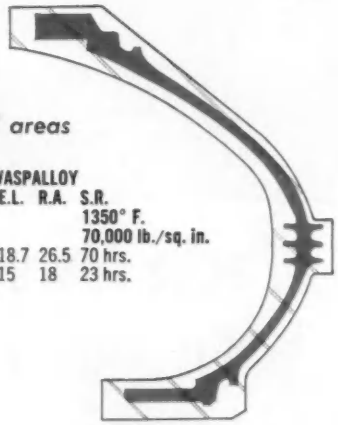




SPECIFICATIONS — MATERIAL: INCO 901

	T.S.	Y.S. 0.2%	E.L.	R.A.	S.R. 1200° F. 90,000 lb./sq. in.
Obtained Val.	190,400	132,000	15.6	16.7	68 hrs.
Spec. Val.	165,000	120,000	12	15	23 hrs.

THERMAL SHIELD TURBINE ROTOR and half cross section showing forged and machined areas



SPECIFICATIONS — MATERIAL: WASPALLOY

	T.S.	Y.S. 0.2%	E.L.	R.A.	S.R. 1350° F. 70,000 lb./sq. in.
Obtained Val.	190,800	143,000	18.7	26.5	70 hrs.
Spec. Val.	160,000	110,000	15	18	23 hrs.

Turbine components made from Cameron forgings have hit a new high in forming and in metallurgical refinements, developing not only room temperature properties up to 20% over specifications but, more importantly, producing the same over-specification values at elevated temperatures.

With Cameron's special forging techniques, using one heat and one push, uniform properties are produced from surface to center and from hub end to flange end. Even in high density alloys, interesting economies are effected. Favorable billet to finished forging weight ratio means less of the expensive material is used in each operation. Because of improved grain structure and close controls throughout the entire process, machining qualities are excellent.

With Cameron forging techniques, our customers receive a better component functionally and economically. Check the accompanying comparison of specification values and obtained values on the two turbine forging components shown – let us show you what can be done with your problem forgings – just CALL, WRITE, or COME BY

Cameron

CAMERON IRON WORKS, INC.
SPECIAL PRODUCTS DIVISION
P. O. BOX 1212 • HOUSTON, TEXAS

*INCO 901 • A 286 • WASPALLOY • RENE 41 • UDIMET 700
MOLYBDENUM • COLUMBIUM • TANTALUM TUNGSTEN • TITANIUM

Briefs of SAE PAPERS

These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

AEROSPACECRAFT

VTOL Wind Tunnel Testing Techniques and Facilities, R. C. McWHERTER. Paper No. 370A. VTOL machines are classified according to disk loading, i.e., vehicle weight fraction per square foot of area swept-out by rotor or other thrust device; special VTOL test and analytical problems; wind tunnel data corrections, and special transition data reduction; VTOL test facilities at Chance Vought Corp. comprising cruise, transition and hover test station; proposed Vought ADAM deflected jet VTOL machine, fundamentals of transition, test procedures and results.

Gust Simulation as Applid to VTOL Control Problems, W. J. KLINAR, S. J. CRAIG, Jr. Paper No. 370C. Review of available statistical data applicable for VTOL operation, and control information obtained during simulated Instrument Flight Rules flight for particular VTOL vehicles with weather conditions simulated at Chance Vought Corp.; test results showed that there was not appreciable difference between hovering in still air or hovering at 10 knots under gusty conditions; time histories obtained during still air tests and tests at 30 knots under gusty conditions.

Allison Unit Exchange Plan for Electra Engines and Propellers, R. W. SHERK. Paper No. 373B. Features of Allison plan which makes available to airline operator "pool" or "float" of engines, QEC's "Quick Engine Change" and propellers for immediately delivery; QEC is power nacelle, including engine and structural portions of airframe, but not propeller; advantages to airlines; experience gained and tabulation of Electra Operators overhaul and unit exchange summary.

TWA's Engine Overhaul System, L. SPRUILL, T. B. KING. Paper No. 373C. Design concept applied to Trans World Airline's Powerplant Overhaul shop, built to produce 8 piston engines overhauls per day on 8-hr basis. Layout of shop floors, shop organization and operation; cost control; handling of rotable parts; special production aids such as grouping jet engine parts by assemblies, charts used, jet engine inspection methods and procedures, and handling of miscellaneous small parts and hardware items.

Measurement of Total Radiant Energy from Jet Combustor Flames, R. M. SCHIRMER. Paper No. 379E. Combustor failure caused by cracks in inner liner of aircraft gas turbines is caused by thermal stresses induced by large temperature gradients; radiation component can be predominant factor in determining liner temperature; requirements for taking observations of radiation; measurement of total radiant energy should include infrared spectral region through 5μ using sapphire optical materials and total radiation pyrometer such as double mirror Raytube. 20 refs.

Gas Turbine Shaft Dynamics, G. HAMBURG, J. PARKINSON. Paper No. 382B. Study of effect of compliance in bearing support structure on critical speeds for high speed turbine rotors; compliance can be adjusted by means of cantilever spring system of much lower stiffness than general structure; use of model to examine vibrational characteristics of proposed engine design prior to commencing full scale development of Continental Aviation and Eng. Corp. Model 217-5 turboshaft engine; no major modifications of shaft system were required.

The Air Force B-70 Valkyrie — An Example of Next Generation Aerospace Vehicles by LATHAM POLLOCK. Paper No. S308. Covers the fabricating techniques used in the B-70, some of the welding operations, use of brazed fittings in coupling hydraulic tubes together, fabrication of honeycomb panels, and "skate" machining.

The Lockheed Jetstar, E. B. GIBSON. Paper No. S310. A profusely illustrated, complete technical de-

continued on p. 6

TEAR ALONG PERFORATION

Readers' Information Service

Advertising Information Available

- If you would like further engineering information on any of the products ADVERTISED in this November 1961 issue, CIRCLE THE APPROPRIATE PAGE NUMBERS in the list BELOW. Requests will be forwarded to the advertisers.
- Please fill in your NAME, COMPANY, AND ADDRESS on the BACK of this form.

3	127	150	174
4	128	151	175
8	129	152	176
9	130	153	177
10	131	154	178 left
11	132	155	179 top
12	133	156	181
13	134	157	182
14	135	158	183
15	136	159	184
16	137	160	185
17	138	161	186
18	139	162	187
19	140	163	189 top right
20	141	164	189 bottom right
22	142	166	189 left
23	143	167	190
24	144	168	191
25	145	169	193
26	146	170	194
28	147	171	Inside front cover
125	148	172	Inside back cover
126	149	173	Outside back cover

- COMPLETE PAPERS on which November, 1961 SAE Journal articles are based are available in multilith form. CIRCLE PAPER NUMBERS ON THE BACK OF THIS FORM of any papers you wish to buy.

Briefs of SAE PAPERS

continued from p. 5

scription of the Lockheed Jetstar — designed to be a utility cargo airplane powered by four jet engines and capable of carrying 10 people for a range of over 1500 nautical miles at high altitudes and speeds. First prototype was flown in 1957; production was started in November, 1958. Target date for an FAA type certificate is Fall of 1961.

ENGINEERING EDUCATION

How Industry Educates Engineers to Use Digital Computers, J. L. DAVIE. Paper No. 372B. Educational system recommended as means for industry to utilize electronic data processing equipment should comprise: periodic seminars for middle and top management, training classes for supervisors dealing with present and future application areas; training classes for engineer engaged in work where computer applications exist; basic course to provide training for supervisor and engineer given at McDonnell Automation Center; suggested computer training program.

Progress in Teaching Engineering Students to Use Computers, D. L. KATZ, B. CARNAHAN. Paper No. 372A. At Univ. of Michigan, most of engineering programs require sophomore level course on Introduction to Computing Techniques which consists of one hour of lecture and one hour of recitation per week for 15 weeks; basic elements of programming process are given in lectures with introductory numerical methods; students are given 3 problems to solve; typical set assigned and solution with flow diagram and program written in MAD language is given.

FUELS & LUBRICANTS

Two-Cycle Engines Require Special Oils, C. C. COYLER, W. L. SIEKER. Paper No. 371A. Laboratory test program at American Oil Co., Whiting, Ind., shows that base oils satisfy neither small air cooled nor large water cooled outboard engines; additives designed for 2-cycle engines can provide performance properties needed; as oil is supplied with fuel, gasoline additives have pronounced effect on performance of oils; lead reduces engine cleanliness and increases harmful combustion chamber deposits; phophorus additives promote spark plug fouling and preignition.

Preignition Studies in Two-Stroke Cycle Gasoline Engines, H. V. LOWTHER, K. C. KRESGE. Paper No. 371B. Lubricating oil and gasoline, because they are mixed before use in 2-cycle outboard engine, affect lubrication and fuel combustion; study made at Socony Mobil Oil Co., Inc. investigating fuel phosphorous content, tetraethyl lead content, lubricant base oil, detergents, and phosphorous content; table showing effect of changing fuel components and oil components; nonleaded, nonphosphorous gasoline would be best fuel for controlling preignition rate.

Preignition in Two-Stroke Cycle Spark-Ignited Engines, B. K. GHANDHI. Paper No. 371C. Basic differences between 2-stroke and 4-stroke cycle engines; phenomenon of preignition in 2-stroke cycle engine and its effects; studies made by Outboard Marine Corp. to determine influences of fuels and lubricants and effects of engine design. 22 refs.

Study of Low Temperature Sludge Techniques, R. D. QUILLIAN, Jr., J. V. MOFFITT. Paper No. 374A. Study of factors that influence sludging process and evaluation technique developed for MIL-L-2104B lubricating oil specification at Ordnance Fuels and Lubricants Research Laboratory Southwest Research Inst.; types of techniques investigated and operational variables, fuel characteristics, blowby, oil consumption and test temperature; development of deposition technique having maximum severity consistent with desired discrimination, repeatability and reproducibility; principal operating conditions.

Development of Diesel Detergency Test for Specification MIL-L-2104B, J. W. VOLLENTINE. Paper No. 374B. Because of low load and speed of CRC L-1 Test compared to current and expected future engines, new test was suggested for MIL-L-2104B Specifica-

continued on p. 134

TEAR ALONG PERFORATION

Readers' Information Service

SAE Papers Available — November 1961 issue

• If you would like complete copies (in multilith form) of papers on which November SAE Journal articles are based, CIRCLE THE APPROPRIATE PAPER NUMBERS in the list below. PAPER NUMBERS are indicated at the END of each article. PRICES are listed below.

S297	370A	374C	380F	398A	423D
S305	370C	379A	381A	398E	427B
S308	371A	379B	381B	402A	428A
S310	371B	379C	382B	404B	428B
S311	371C	379D	383A	406A	438B
321B	372A	379E	384A	412A	SP-222
359C	372B	379G	385A	414A	
369A	373B	379H	388B	415B	
369B	373C	380B	394A	419A	
369C	374A	380D	396C	420A	
369D	374B	380E	397A	421A	

PRICES: Papers; light face numbers; 50¢ each to members; 75¢ each to nonmembers.
Papers; bold face numbers; 75¢ each to members; $1.00 each to nonmembers.
SP-222; $4.00 each to members and nonmembers.

ORDER BLANK

TO: Society of Automotive Engineers, 485 Lexington Ave., New York 17, N.Y.

PLEASE SEND ME:

... The SAE Papers and Special Publications whose numbers I have circled above.

.... Check or coupons enclosed

.... Bill Company .... Bill me

PLEASE SEND ME:

... Information about the advertisers' products and services circled on the back of this form.

NAME .....

COMPANY .....

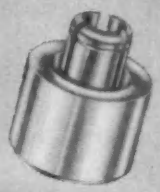
COMPANY ADDRESS .....

HOW MANY WAYS CAN *Special Purpose Fasteners* CUT COSTS FOR YOU?

How many of your products employ laborious, old-fashioned fastening methods where simple fasteners could do the job and cut costs, too? How many parts and sub-assemblies can be adapted to include a self-fastening feature? How many future products could be improved by advance planning for fastener efficiency?

United-Carr's engineering staff offers you a wealth of experience in the design of special-purpose fasteners and self-fastening devices. Large-scale manufacturing facilities (including in-plant plastics molding equipment) ensure economical, *volume* production and prompt deliveries. United-Carr field representatives are ready to call on you at *your* request.

POLYETHYLENE MOUNTING FOOT



No mar, no scratch glide for use on TV receivers, record changers, small appliances, etc. Assembles into round hole in wood or metal cabinets.

The names DOT, TEENUTS, TRIMOUNT are registered trade-marks of United-Carr Fastener Corporation

NYLON SNAP-IN NUT

Snaps into square hole stamped out of sheet metal . . . provides secure anchorage for any sheet metal or self-tapping screw . . . highly effective electrical insulator.

QUICKEY FASTENER

Eliminates need for welding or swaging studs to sheet metal stampings, facilitates nesting, eliminates damage in transit because Quickey snaps in before final assembly.

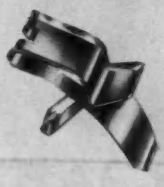
6-PRONG TEENUT

Offers greatly increased push-out resistance; virtually eliminates the problem of lost fasteners, cuts rejections, customer complaints, etc. Claw-like prongs toe in for maximum gripping power.

PLUG BUTTONS

Snap into ⅛" to 3" dia. holes. Can be embossed with ornamental or functional designs . . . various finishes, shapes and sizes.

WIRING FASTENER



Mounting legs snap into round hole . . . provide secure anchorage. Body of fastener holds wires without chafing.

MOLDING FASTENER

Ideal for use with thread cutting fasteners or available with threaded stud for nut and lock washer assembly. Spring leg maintains tension to keep fastener blade locked in molding channels.

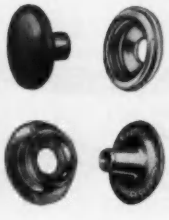
TEENUT

One-piece, all-metal nut has welding bosses on upper or lower surface of mounting flange. Has high tensile strength and provides secure, permanent anchorage for bolt. Available in various shapes and sizes.

TRIMOUNT STUDS

Hold two or more thicknesses of material together. Easily installed by hand. Insure vibration proof attachment. Permanent or removable. Many shapes and sizes.

DURABLE DOT FASTENER



Snap fastener for cloth, leather, plastics and other materials. Positive closure, instant release. Black, nickel or brass finish.

MAKERS OF ★ DOT ★ PRODUCTS

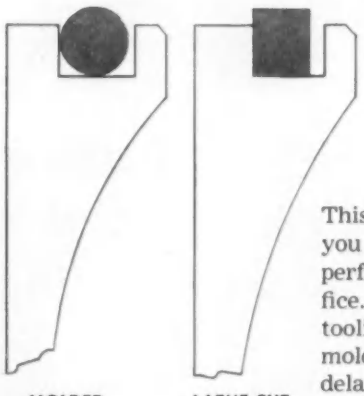
CARR FASTENER COMPANY

Division of United-Carr Fastener Corporation, Cambridge 42, Mass.

Offices in: Atlanta, Boston, Chicago, Cleveland, Dallas, Detroit, Kalamazoo, Los Angeles, Louisville, New York, Philadelphia, San Francisco, Seattle, Syracuse

Why ACADIA LATHE-CUT SYNTHETIC RUBBER SEALS

can save you money in *STATIC* or *MOVING* seal applications



MOLDED O-RING SEAL

LATHE-CUT SEAL

This seal will save you money with no performance sacrifice. Minimum tooling cost, no molds, no costly delays. Can be made up to 25" I.D.

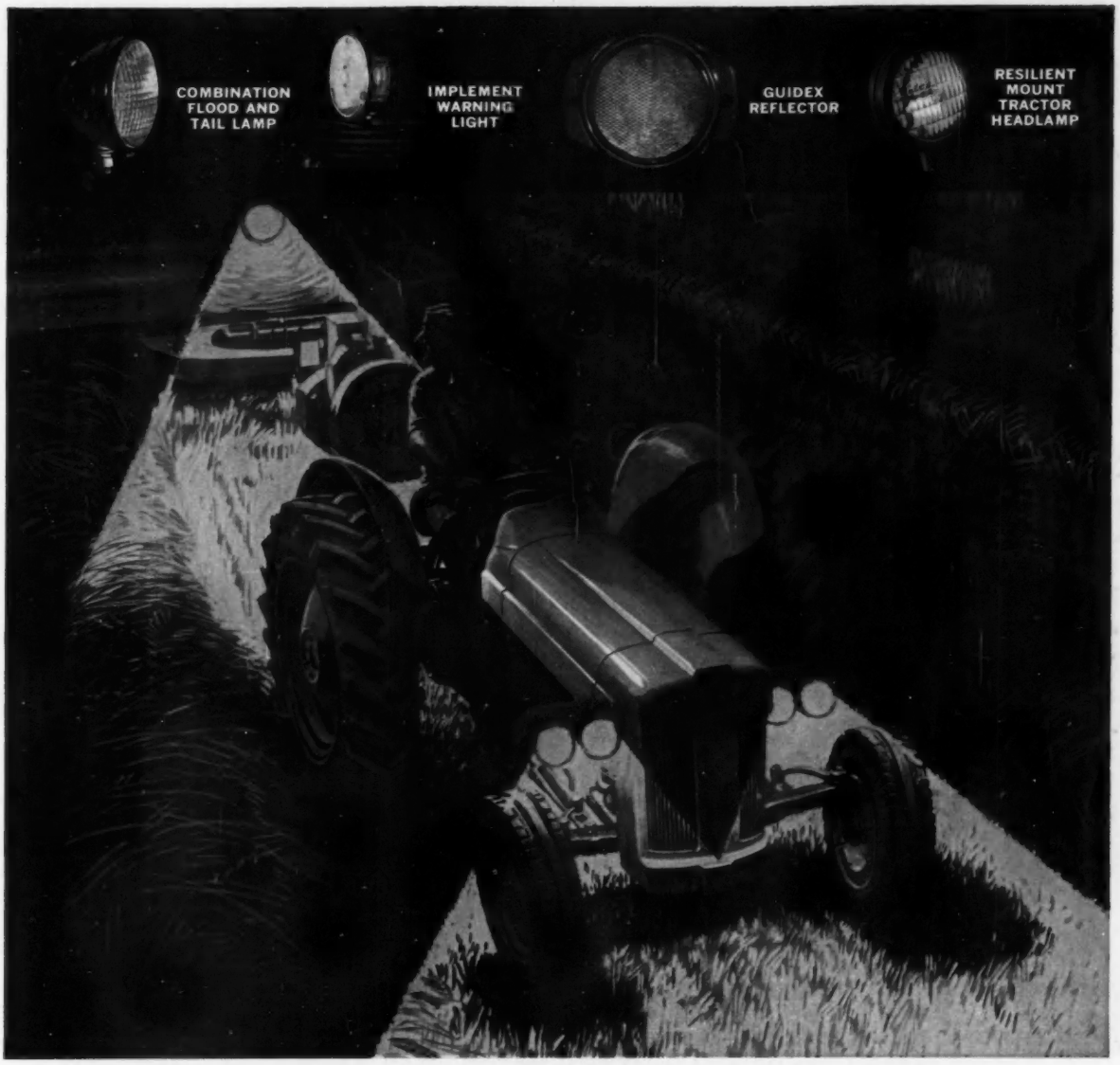
Acadia Synthetic Rubber Parts are of the highest quality components, processed for oil resistance, good aging properties, resistance to heat. They can be furnished in any dimension or special compound you desire to precision tolerances. They are another example of Acadia's ability to SAVE YOU MORE..SERVE YOU BETTER.

There's an Acadia Sales engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA *Synthetic* PRODUCTS

DIVISION OF WESTERN FELT WORKS
Dept. S, 4021-4139 West Ogden Avenue, Chicago 23
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT



EQUIP YOUR TRACTORS TO MAKE HAY ROUND THE CLOCK

WITH GUIDE'S 4-BEAM HEADLAMP SYSTEM, America's leading tractor manufacturers and dealers are harvesting the benefits of an expanding market.

Alert farmers keep going after dark to beat seasonal deadlines or threatening weather. Guide's 4-Beam Headlamp System equips tractors for duty round the clock. With the Guide system, there's light aplenty for haying, hoeing or harvesting.

Guide Lamp offers other applications for original equipment and the replacement market. Guide Lamp accessory work lights, warning lights, taillights and Guidex reflectors help you put farming on a round the clock basis.

Put Guide Lamp equipment on all your farm vehicles and assemblies. There will be a payoff in profit for you and the farmer.

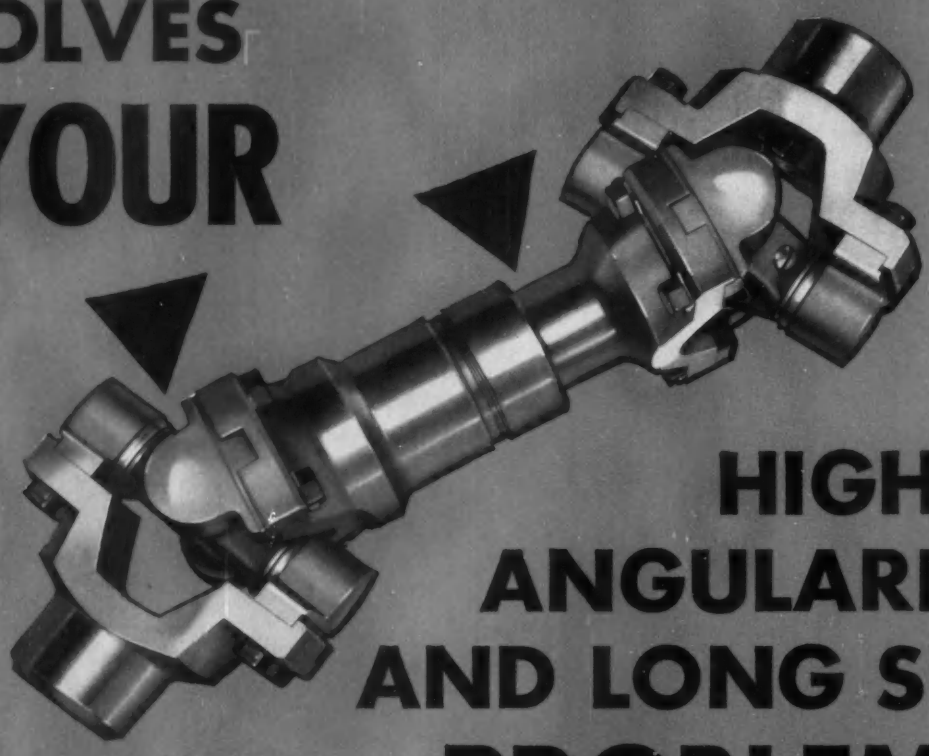
GUIDE LAMP

FOR BETTER TRACTOR LIGHTING

GUIDE LAMP DIVISION, GENERAL MOTORS CORPORATION, ANDERSON, INDIANA

MECHANICS

SOLVES YOUR

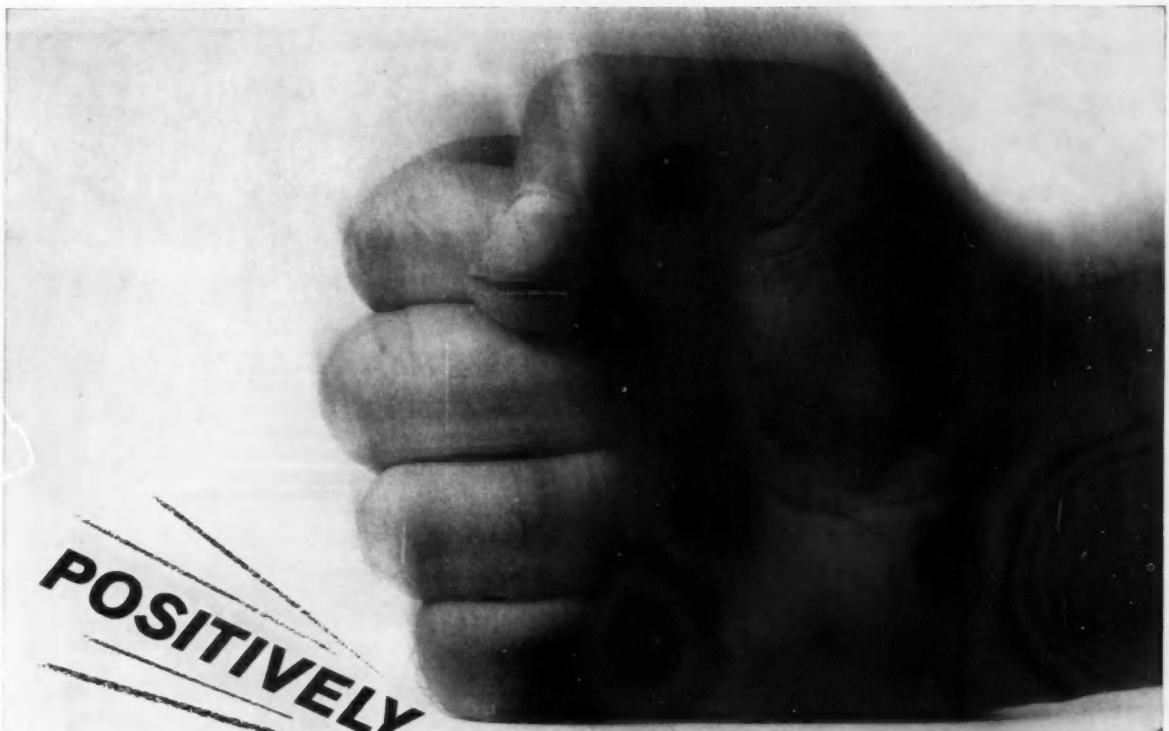


HIGH ANGULARITY AND LONG SLIP PROBLEMS

In road building, agricultural, and industrial fields where joints must be capable of operation at angles up to 35% — where there are severe shock loads — where dirt and moisture are continually present—and where wide angles and long slip problems are common, designers have learned to rely on MECHANICS for the correct solution. Lubrication is so tightly sealed in that dirt and moisture cannot enter. Let MECHANICS' engineers help you solve your "tough" joint problem. Write today for additional information.

MECHANICS UNIVERSAL JOINT DIVISION
BORG-WARNER CORPORATION
2022 HARRISON AVENUE ROCKFORD, ILLINOIS
Export Sales: Borg-Warner International • 36 So. Wabash, Chicago 3, Illinois
Roller Bearing Joints For Cars • Trucks • Tractors • Farm Implements •
• Road Machinery • Aircraft • Marine • Busses and Industrial Equipment •

MECHANICS B-W UNIVERSAL JOINT • BORG-WARNER



POSITIVELY

TOTAL QUALITY CONTROL

You get better, more uniform oil seals as a result of National's 4-part quality program

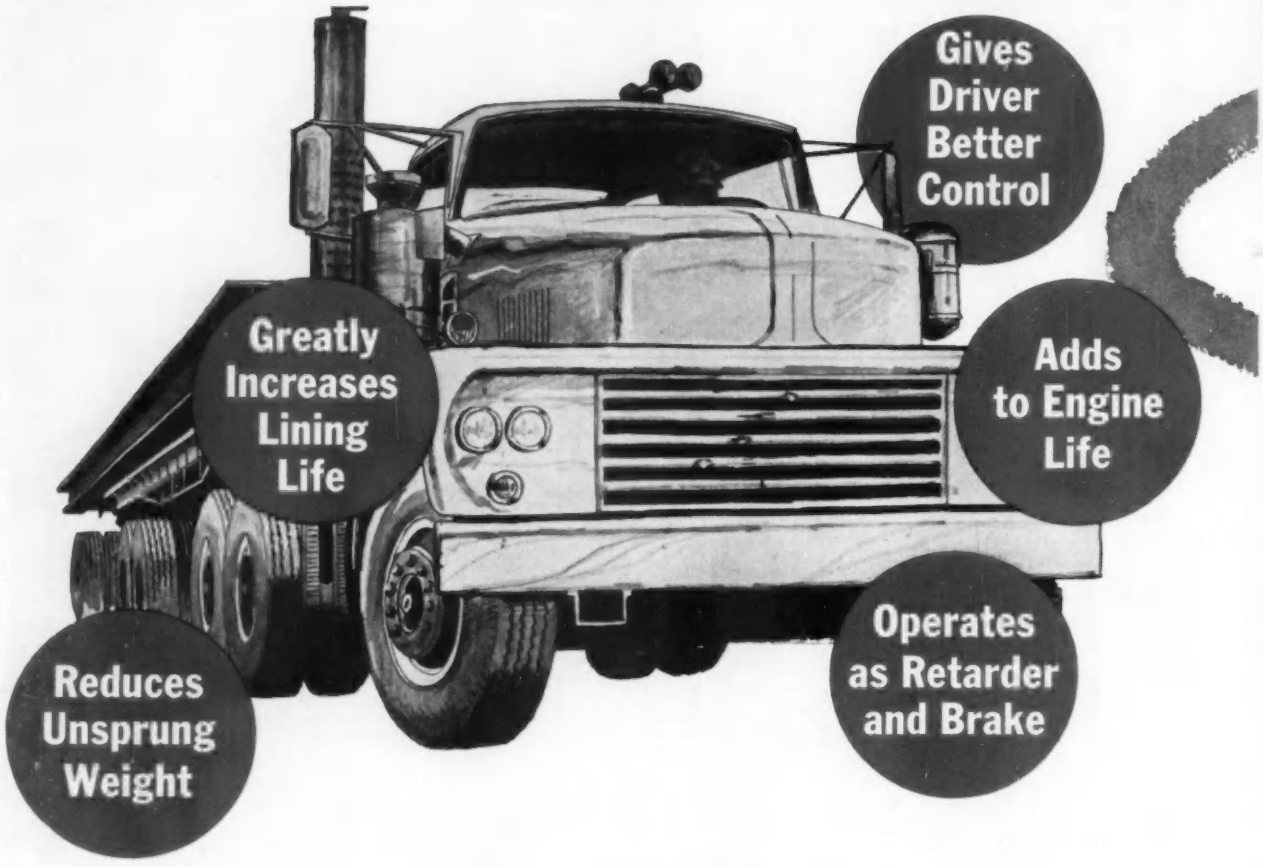
1. New Seal Design
2. Incoming Materials
3. In-Process Control
4. Quality Assurance

In these four separate areas National follows rigid quality control mandates.

Quality Control Managers and teams reporting directly to National's General Manager work with Engineering to establish AQL's—Acceptable Quality Levels—for all new products. They supervise careful inspection of all raw materials in National Seals. They provide production inspection, monitoring performance of Manufacturing and developing new methods of in-process control. And finally, Quality Assurance, which is the periodic, random re-testing of production parts.

For dependability in seals, and the nation's finest oil seal engineering help, call your National Seal Applications Engineer (Yellow Pages under "Oil Seals") or write direct.

NATIONAL SEAL DIVISION, FEDERAL-MOGUL-BOWER BEARINGS, INC.
GENERAL OFFICES: Redwood City, California
PLANTS: Van Wert, Ohio; Redwood City and Downey, California


Gives Driver Better Control
Greatly Increases Lining Life
Adds to Engine Life
Reduces Unsprung Weight
Operates as Retarder and Brake

Now you can end the operating restrictions imposed by the danger of brake fade

The new Wagner® Lockheed® Liquid-Cooled Disc Brake is a revolutionary truck brake development. Heat generated in the disc brake is immediately dissipated into the vehicle's radiator system. Brake fade is eliminated.

This liquid-cooled brake, installed on one axle, effectively retards and helps stop the vehicle on long grades or in heavy traffic. Drivers have better control, with full braking available at all times. Service brake lining life is increased by many thousands of miles, allowing trucks to be operated longer between reline periods. The need for using lower gears on long downgrades is reduced, engine life is prolonged. Unsprung vehicle weight is reduced.

Thoroughly Test Proved—Months of laboratory tests, months of controlled testing at Wagner's Jennerstown, Pennsylvania proving grounds, cross country road testing over America's toughest commercial truck routes, and actual "in use" tests by leading fleets have throughly proved that these Wagner Liquid-Cooled Disc Brakes will provide greater safety and drastically cut truck downtime and brake maintenance costs.

Interchangeable with Other Foundation Brake Assemblies—Since this liquid-cooled brake can be mounted on a standard axle, it is interchangeable with other types of foundation brakes. Fleet owners can make the change-over on their present equipment—vehicle manufacturers can simplify inventory and reduce assembly line problems.

Wagner® Lockheed

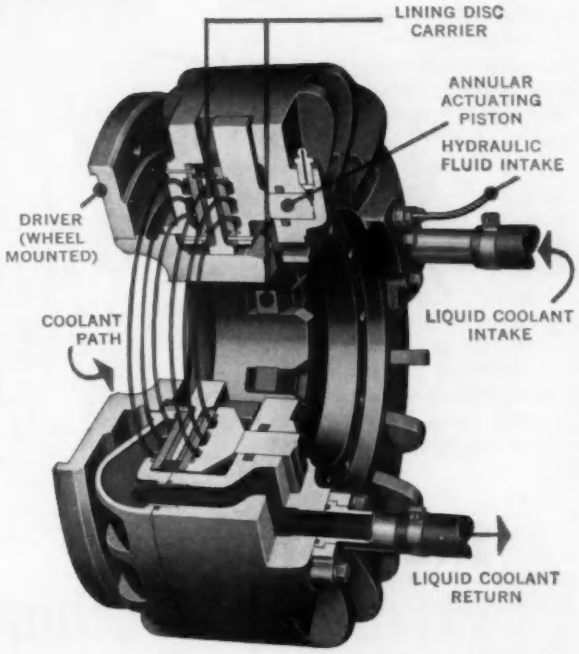
NEW WAGNER®-LOCKHEED®
LIQUID-COOLED DISC BRAKES
DISSIPATE HEAT...ELIMINATE BRAKE FADE

How the Liquid-Cooled Disc Brake System Works

Liquid coolant used in the brake is simply routed from the vehicle's radiator cooling system to a surge tank; then, with the help of a pump, coolant is circulated to the brakes. The surge tank may be eliminated if the radiator top tank is large enough to allow for fluid expansion.

This system lends itself especially well for conventional driving since brake cooling is not needed when the vehicle is ascending a hill. On the other hand, when the brakes are needed for stopping or decelerating on a hill, the engine has less need for cooling by the radiator, and the use of the brake prevents engine overcooling on long downgrades.

The brake, illustrated at right, is designed for air-over-hydraulic actuation, using a power cluster. The outer and inner housing of the brake comprise a cast aluminum housing. The annular actuating piston is also aluminum and is sealed by "O" ring piston seals. Brake lining is bonded to the steel lining carrier. The inner periphery of this carrier is slotted to mate with the teeth on the driver, which is bolted on the wheel. Copper friction plates are attached and sealed to the outer housing and the copper carrier.



Liquid coolant can enter on either side of the brake, depending on the axle mounting and flow through the coolant passages to the back side of the copper friction plates. The brake is protected from road splash and dirt and contains no running seals.

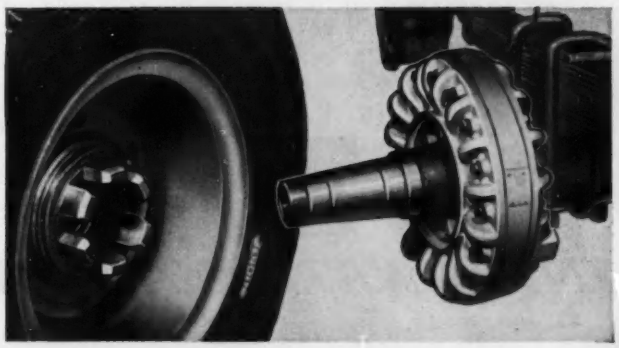
For Complete Information, Write

Wagner Electric Corporation

6378 PLYMOUTH AVENUE, ST. LOUIS 33, MO., U.S.A.

Manufacturers of LOCKHEED® Products

Attn: Sales Manager,
Liquid-Cooled Brake Systems



WA61-10

IPC adds service time to your end product with "RULON"...*

the tested... filled fluorocarbon material for packings and oil seals

IPC now incorporates "RULON"* . . . a *filled fluorocarbon plastic material* . . . in packings, oil seals or precision molded products to answer your most critical sealing problems.

This new combination . . . "custom" molded and bonded for your specific application offers many advantages: Superior abrasion resistance, lower friction, improved sealing, less torque and reduced shaft wear.

Special molding and bonding techniques, developed by IPC for "RULON"* insure long wear and excellent performance. For your critical applications investigate the extras of IPC's latest "custom" approach! You'll find more benefits in handling increased pressures . . . higher shaft speeds . . . and temperature problems too!

**Trade Name of Dixon Corporation.*

IPC

OIL SEALS / PACKINGS / PRECISION MOLDING *Custom designed for your application.*

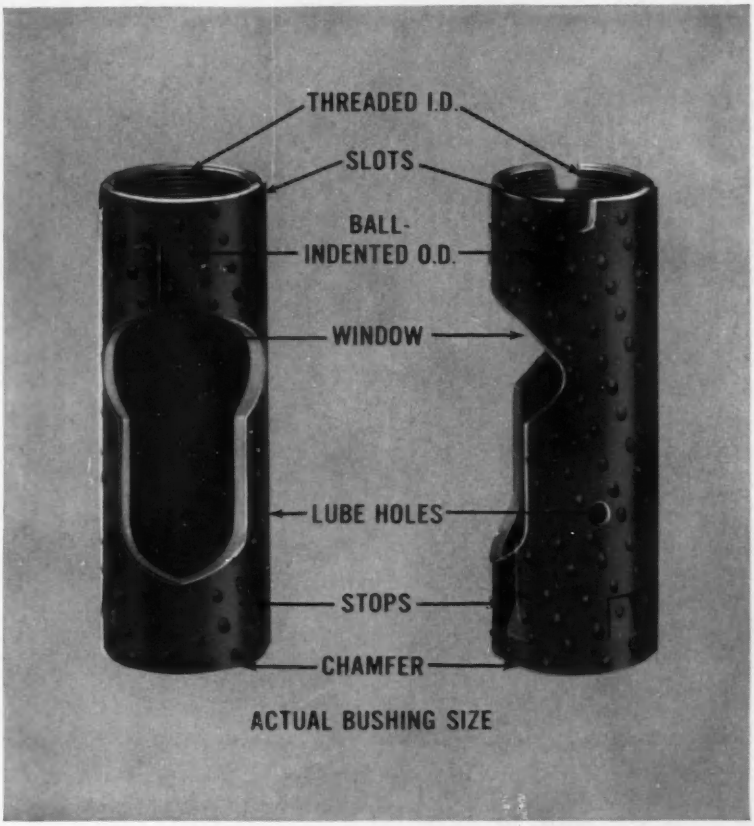
INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

© IPC

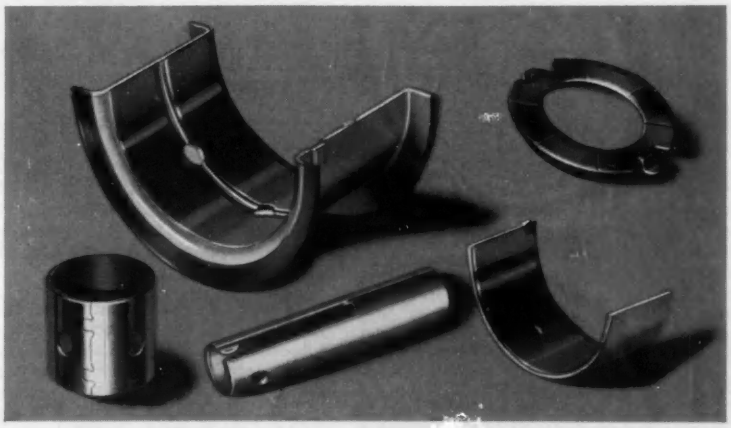
P-2

"EXOTIC" BUSHING MAKES NEW STEERING DESIGN COME TRUE



INSIDE-OUT BUSHING HELPS PUT NEW STEERING MECHANISM INTO PRODUCTION! To perfect a new steering mechanism, an automotive manufacturer required a linkage component. Designers tried making it of machined steel, then plastic . . . both materials failed. But the unusual bushing shown at left, with a number of features F-M engineers helped designers incorporate, solved the problem. It is bronze-on-steel, formed with the ball-indented bronze on the O.D. so the bushing can accommodate sliding motion within the mechanism. A large window makes insertion of a ball socket easy during assembly. Design of the bushing also includes: stops near one end to hold a disc . . . a threaded I.D. on the other with slots for a locking pin . . . holes that supply lubricant to the outer surface. For the F-M customer, all these built-in features helped accomplish this result—easy, efficient assembly and success with a new design.

CAN F-M BUSHINGS SOLVE problems on your board or on your assembly line? Or perhaps a sleeve bearing, thrust washer or spacer? F-M, who makes them all, can provide the answer. F-M engineers, with a wealth of knowledge from years of experience, are available to help design the needed component. This complete technical assistance is one reason why these F-M products are widely specified for use in automobiles, farm equipment, construction machinery and many other products.

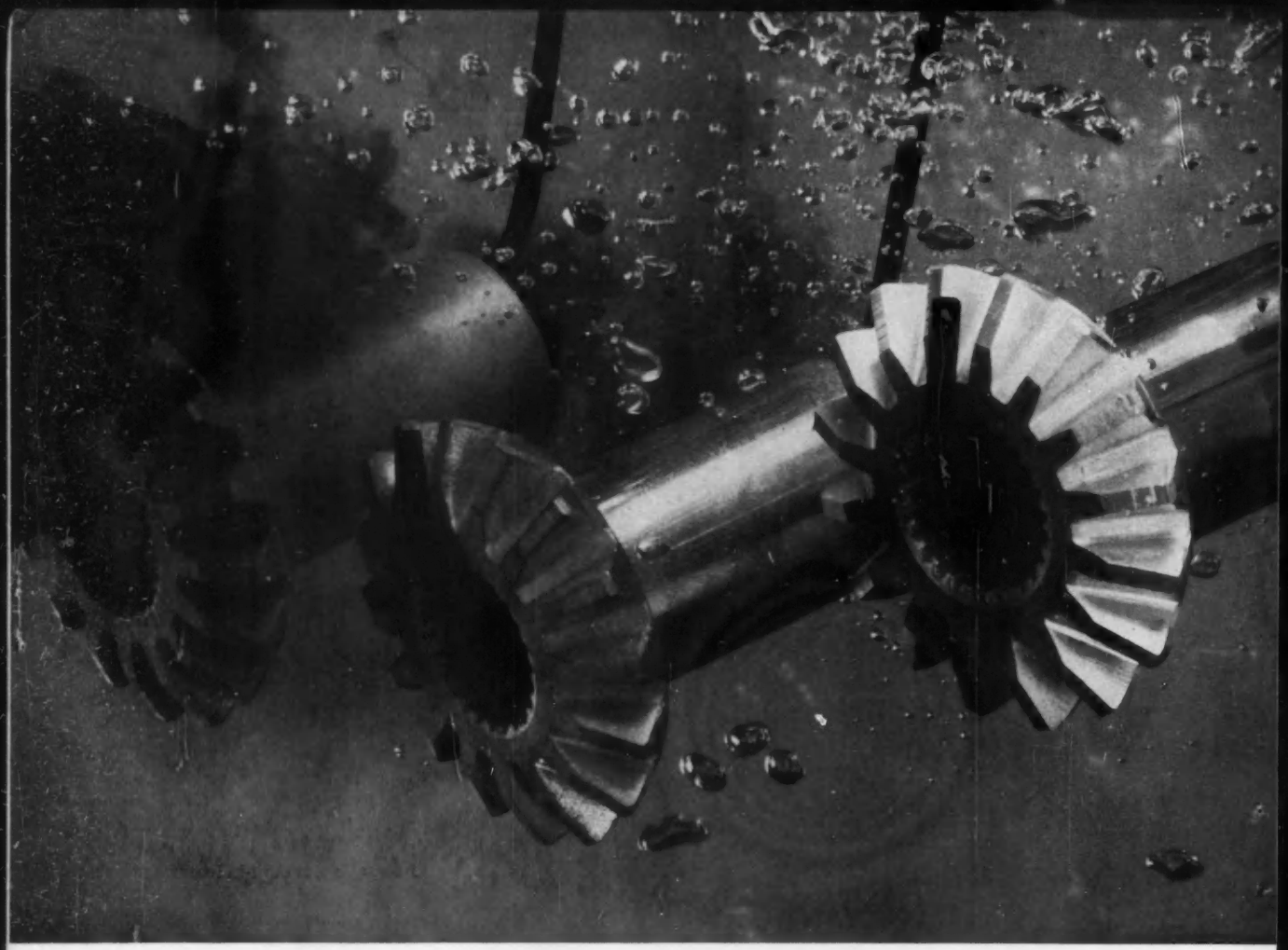


Additional information about bushings is provided in a Design Guide, published by F-M. Helpful literature is also available on sleeve bearings, thrust washers and spacer tubes. For your copies, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11035 Shoemaker, Detroit 13, Michigan.

FEDERAL-MOGUL

sleeve bearings
bushings-spacers
thrust washers

DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.



NEW SAFETY SOLVENT permits

on-the-line cold degreasing . . . 100% parts inspection

FAR GREATER SAFETY than most other chlorinated solvents makes Chlorothene® NU specially inhibited 1,1,1-trichloroethane ideal for the cold removal of greases, waxes, tars, and oils. In cleaning for spot inspection of close tolerances, or for 100% inspection as on broaching machine operations, Chlorothene NU may be used quickly and safely by spray, dip, bucket or wiping methods. Die parts may be cleaned in the shop without having to send them out for vapor degreasing.

By providing answers to both of the chief hazards of common cold-degreasing solvents, Chlorothene NU is leading a breakthrough in solvent cleaning. Having *no* fire or flash point measurable by standard methods, it is removed from the flammable class of cleaning compounds. Maximum allowable vapor concentration of Chlorothene NU solvent is a high 500 ppm, compared to carbon tetrachloride at 25. Chlorothene NU is easily recovered by distillation. It can be used safely on most electric motors, instruments, bearings, and on all common metals including aluminum, zinc, corrosion-prone "white-metal" alloys, and on many plastics.

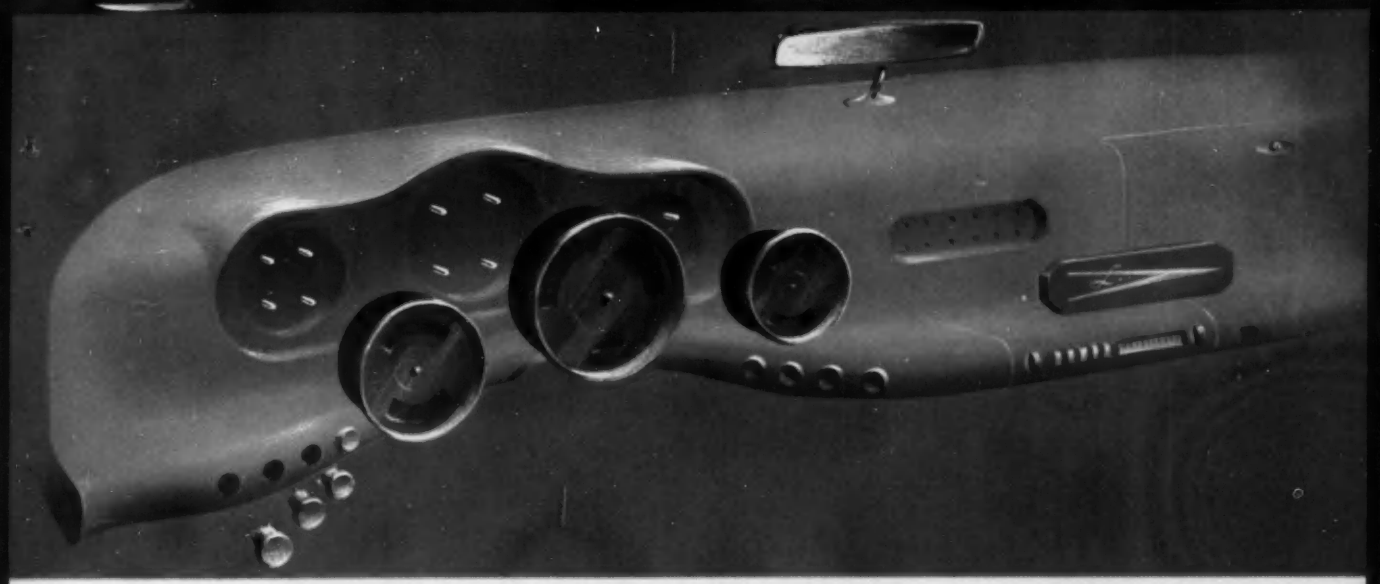
HYDRAULIC FLUIDS continue to be important objects of research at the Dow Automotive Chemicals Laboratory. They are custom engineered, and Dow's broad background in polyols, glycols, and glycol ethers assures hydraulic fluids of the highest quality, and with an almost limitless range of properties.

VORACEL® foamed-in-place rigid urethane offers new advantages for sound deadening, insulating, "pocket" sealing, and strengthening between structural members. The new process gives a superior, and economically feasible covering and filling material for many automotive uses. For additional information, contact your nearest Dow sales office.

DOW AUTOMOTIVE CHEMICALS LABORATORY

Created expressly to serve the needs of the automotive industry, Dow's Automotive Chemicals Laboratory is active in technical service and development. This laboratory is continually researching and developing coolants, hydraulic fluids, cutting and grinding fluids, function fluids, fuel and lubricant additives, and synthetic lubricants. To see how this laboratory can be of assistance to you, contact your nearest Dow sales office or write Chemicals Merchandising in Midland.

THE DOW CHEMICAL COMPANY DOW Midland, Michigan



Looking for a "workhorse" plastic?

Take a look at KRALASTIC. Whatever your engineering area—electrical, body, transmission-chassis, accessories—you'll see why automotive engineers have recognized the advantages of KRALASTIC ABS compounds for an increasing number of applications. The 1961-62 Rambler convertible and station wagons, for example, employ KRALASTIC garnish moldings at substantial savings on tooling and piece price. KRALASTIC instrument cases with integral printed circuits will be found on several 1962 truck and passenger car models.

Why this swing to KRALASTIC? What does it offer to make it one of the fastest-growing materials in the auto industry?

- **high temperature resistance—up to 220°F.**
- **lower thermal coefficient of expansion—can be used adjacent to metal parts**
- **light weight—one-seventh the weight of steel and zinc**
- **high impact strength and good scratch and abrasion resistance**
- **can be vacuum-metalized or painted with commonly used coating systems**

Make a comparison of KRALASTIC's cost per cubic inch versus conventional metals. Consider the lower tool investment vs. metal stampings, the elimination of costly trimming and finishing charges on zinc die castings. Investigate light, strong, versatile KRALASTIC. For further information write Naugatuck Chemical today.

NAUGATUCK CHEMICAL DIVISION

United States Rubber

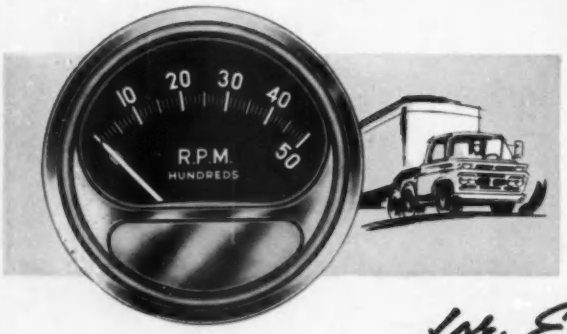
DEPT. A ELM STREET, NAUGATUCK, CONNECTICUT

DIST. OFFICES: Akron · Boston · Chicago · Detroit · Gastonia · Los Angeles · Memphis · New Brunswick, N. J. · Naugatuck Chemicals · Elmira, Ont. · Cable: Rubexport, N.Y.

Drive with famous Sun Instruments and...

KNOW WHAT'S HAPPENING!

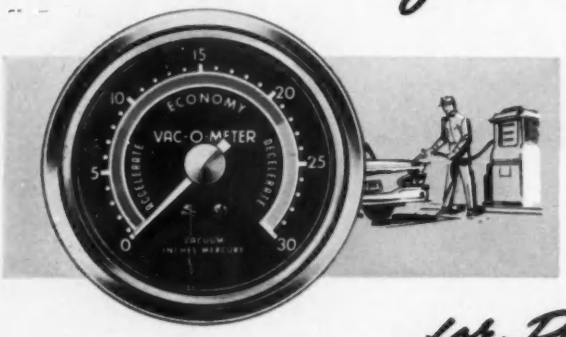
for Dependability



THE SUN F.Z. TACHOMETER

Whether on rugged winding mountain grades or sleek international speedways, the Sun F Z Tachometer delivers a steady, precise reading that lets you drive with confidence. One piece construction, Zener circuity and 99% accuracy, plus Sun's famous "BUILT IN QUALITY" combine to give the F Z Tachometer unmatched dependability under all driving conditions. For Trucks, Passenger, Sports and Racing Cars, Tractors, Busses and Marine inboard engines, Sun F Z *Tachs are Tops* for Dependability.

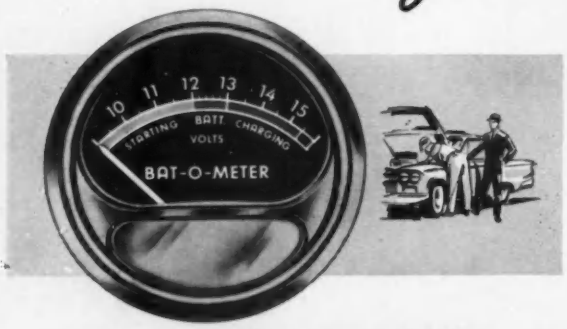
for Economy



THE SUN VAC-O-METER

The Sun VAC-O-METER lets you drive with an eye on economy. When you keep the pointer in the Green economy band, you cruise at gas saving speeds, and you reduce engine and tire wear. The VAC-O-METER also lets you keep an eye on your engine condition—steady gage readings at idle speed indicate a satisfactory running condition—erratic pointer action indicates the need for engine adjustment. Install a Sun quality VAC-O-METER and enjoy new driving economy.

for Protection



THE SUN BAT-O-METER

Electrical ignition failures are costly, inconvenient and avoidable. The Sun BAT-O-METER shows you the applied voltage of your electrical system, actually indicates the electrical condition throughout the entire starting through charging cycle. Any ignition failure is quickly and positively indicated on the BAT-O-METER. You catch failures before they become serious breakdowns, saving time and money. For complete protection and top economy, do as thousands of wise drivers have done—install a Sun top quality BAT-O-METER.

For unmatched dependability . . . economy . . . and protection . . . use the best—Install famous SUN quality instruments and Know What's Happening.

See your nearest distributor or write . . .

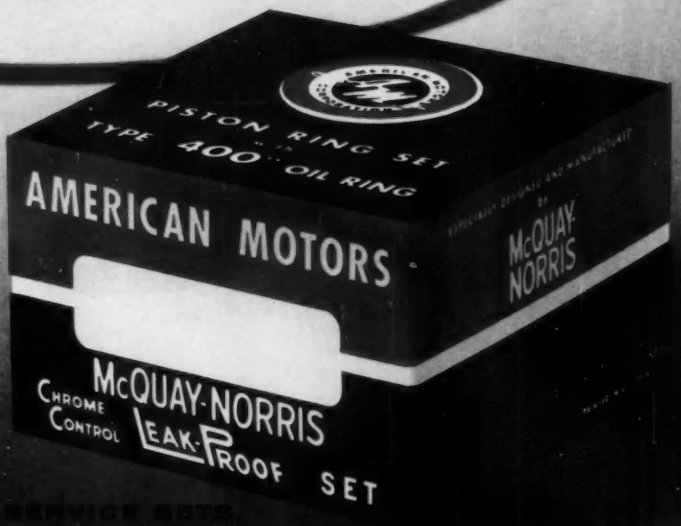
Sun ELECTRIC CORPORATION

TACHOMETER DIVISION

HARLEM AND AVONDALE • CHICAGO 31, ILLINOIS, U.S.A.

Piston Rings...
Sealing Rings

WHEN
RING REQUIREMENTS
CALL FOR
EXTRA *Quality*



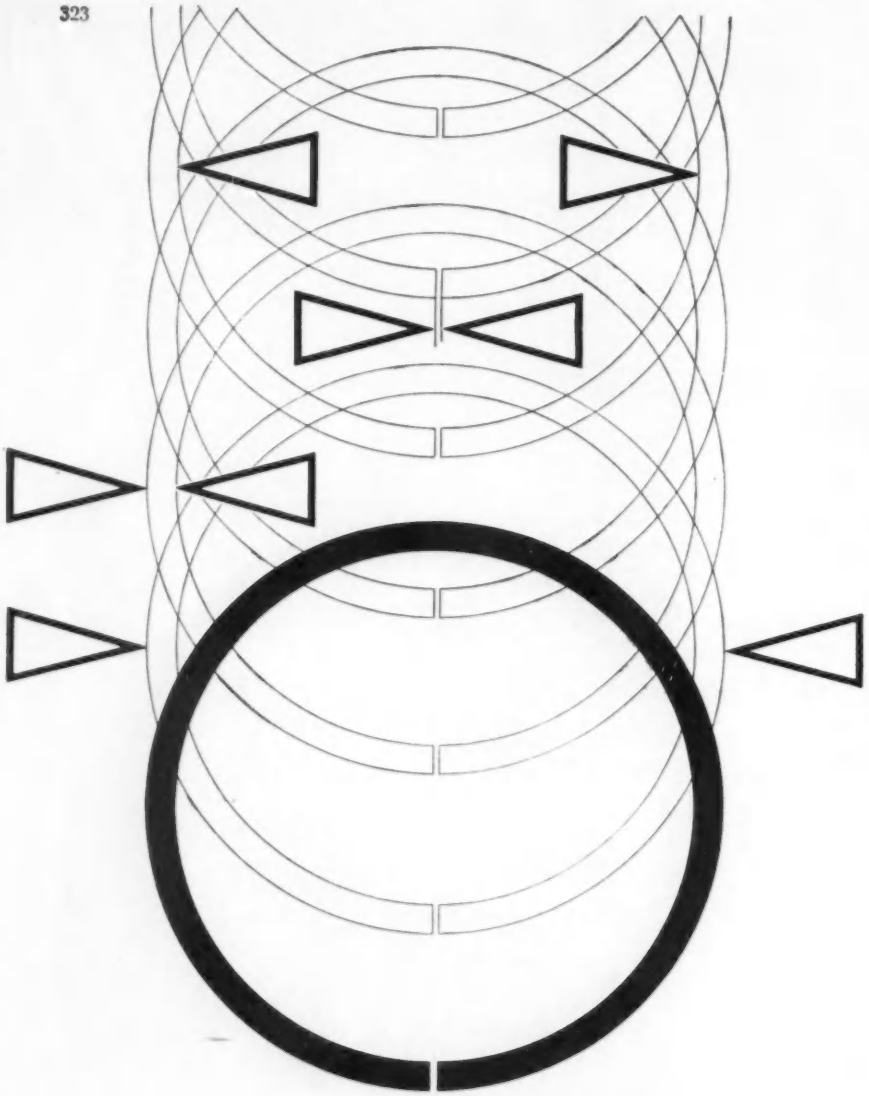
Call on

McQUAY-NORRIS

For more than fifty years McQuay-Norris engineers have worked side by side with original equipment engineers in the design of quality piston rings and sealing rings. With this experience you can be sure that McQuay-Norris can produce rings to your exact specifications, with delivery when and as you need them.

McQUAY-NORRIS MANUFACTURING CO., ST. LOUIS • TORONTO

323

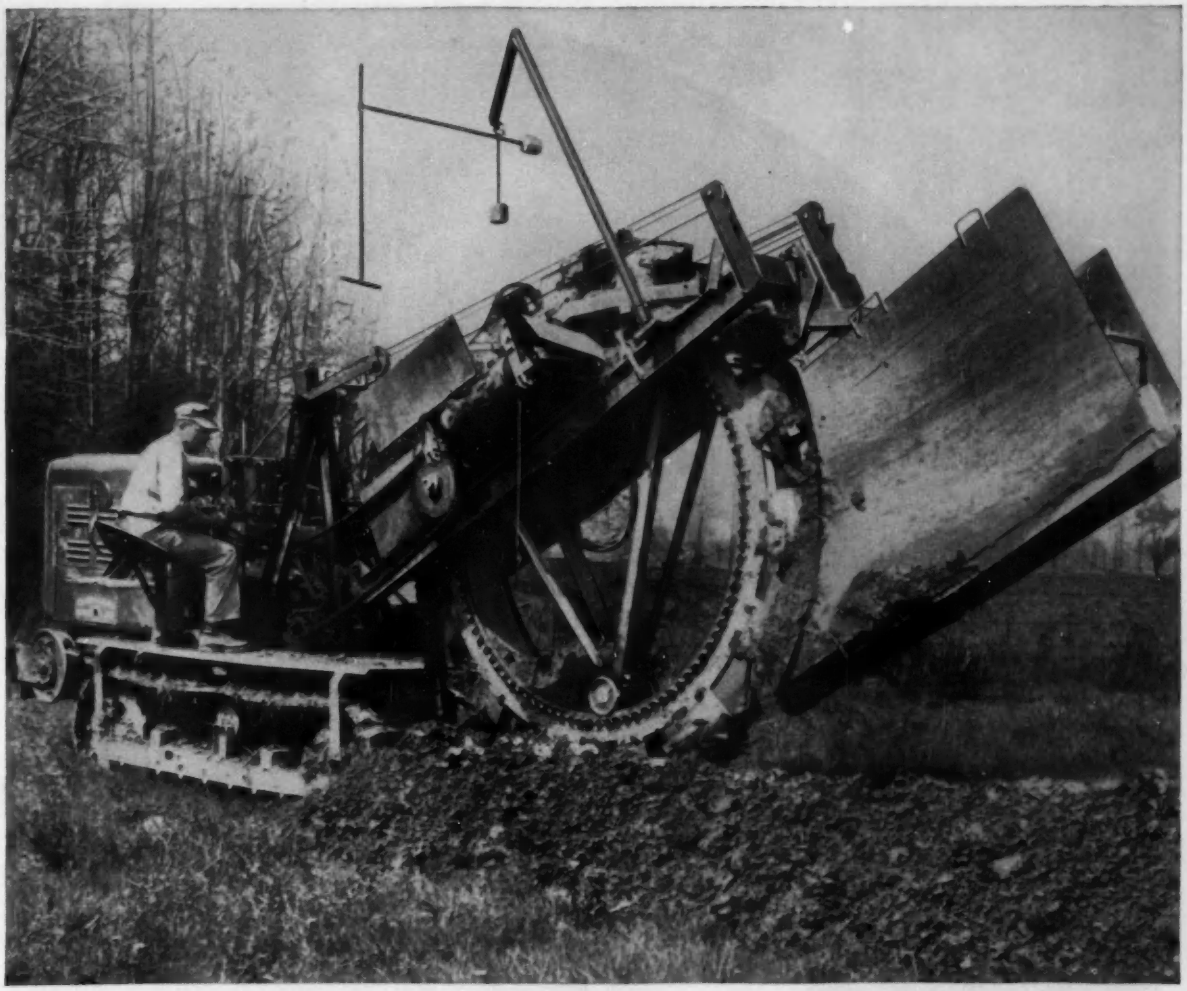


Quality!

Top quality material subjected to constant quality control, finished to precise specifications have given our products an enviable reputation within the industrie.

Regardless what product — GOETZE piston rings, cylinder liners, gaskets, oil seals, mechanical seals, rubber-articles, rubber and metal components or special synthetic rubberproducts —
What we sell is Quality.

Goetzewerke · Friedrich Goetze AG · Burscheid bei Köln



Digs 1,000,000 feet of trench without a breakdown—proof of 4340 nickel steel's strength and toughness!

This through-hardening nickel alloy steel is used in this Cleveland Trencher's traction-output shafts, final-drive countershafts, and digging-wheel lower-truck shafts. Operating loads hit 150,000 psi. AISI 4340 takes these loads in stride – day after day after day!

When this Cleveland Model J-30 Trencher, owned by Mr. Howard Zacharias of Wellington, Ohio, is on the job, components in this trencher have to stand up to operating loads of 150,000 psi. Imagine the shock-loads that occur when the buckets come cracking through the ground – hitting rocks, roots, and buried metal.

With high operating loads, with the constant threat of severe shock loads, designers of the Cleveland Trencher, Model J-30, selected 4340 nickel alloy steel for this trencher's important components – traction output shafts, final-drive countershafts, digging-wheel lower-truck shafts.

4340 pays off in trouble-free performance. Made of a reliable through-hardening steel–strong and tough all the way through – these medium-to-heavy-sectioned parts deliver the abrasion and wear resistance needed for earth-moving service.

But what about your "no-breakdown" experience? Can this nickel alloy steel help you? AISI 4340 nickel alloy steel is readily available off the shelf at Steel Service Centers from coast to coast. It provides the mechanical properties that make for trouble-free performance of a variety of heavily-stressed components in heavy-duty construction equipment—gears, shafts, and bearings. Other nickel alloy steels, possessing special properties for specialized applications, are also widely available.

Write for a copy of the new 76-page booklet, "Nickel Alloy Steels and other Nickel Alloys in Engineering Construction Machinery." It's yours for the asking.

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES STEEL PERFORM BETTER LONGER

HIGH-SPEED TRACK TESTS

prove high temperature quality of Oronite 1200 Series additives

TRACK TEST

Vehicles used: V-8 passenger cars and both gasoline and diesel powered trucks.

(trucks were loaded at normal gross weight to simulate actual driving conditions)

Test driving: 16 hours per day.

Driving speed: Autos—75 m. p. h. *(continuous operation)*
Trucks—60 & 50 m. p. h. *(continuous operation)*

Test miles: 30,000 for each vehicle

Recent road testing demonstrates the high temperature quality of Oronite 1200 Series lube oil additives. 1200 Series additives were previously noted for superior low-temperature performance—NOW their high-temperature quality also has been demonstrated in both gasoline and diesel powered vehicles.

This testing was carried out by an independent facility with high-speed driving conditions simulated for each type vehicle. Test results showed that oils compounded with 1200 Series additives will match any compounded oil on the market for high-temperature engine performance.

Now lab and field testing has demonstrated both high and low-temperature advantages from oils compounded with Oronite 1200 Series additives.

Why not get the complete story? Data is available to those interested in marketing or compounding better motor oils. For full information—contact the Oronite office nearest you.

CALIFORNIA CHEMICAL COMPANY
ORONITE DIVISION

EXECUTIVE OFFICES • 200 Bush Street, San Francisco 20, California
SALES OFFICES • New York, Wilmington, Chicago, Cincinnati, Cleveland, Houston, Tulsa, Los Angeles, San Francisco, Seattle

CALIFORNIA CHEMICAL INTERNATIONAL, INC.
OFFICES • Panama, Sao Paulo, Geneva, Tokyo and San Francisco

7366

Rollway Bearing - equipped pipe - forming and welding stands at J & L Aliquippa Works. Rollways are also used in other equipment at Aliquippa, including cranes, crane hooks and mill motors.

It Pays to Depend On ROLLWAY

The addition of two Continuous Weld Pipe Mills has greatly increased Jones and Laughlin's monthly production of welded pipe. The mills have operated since 1957.

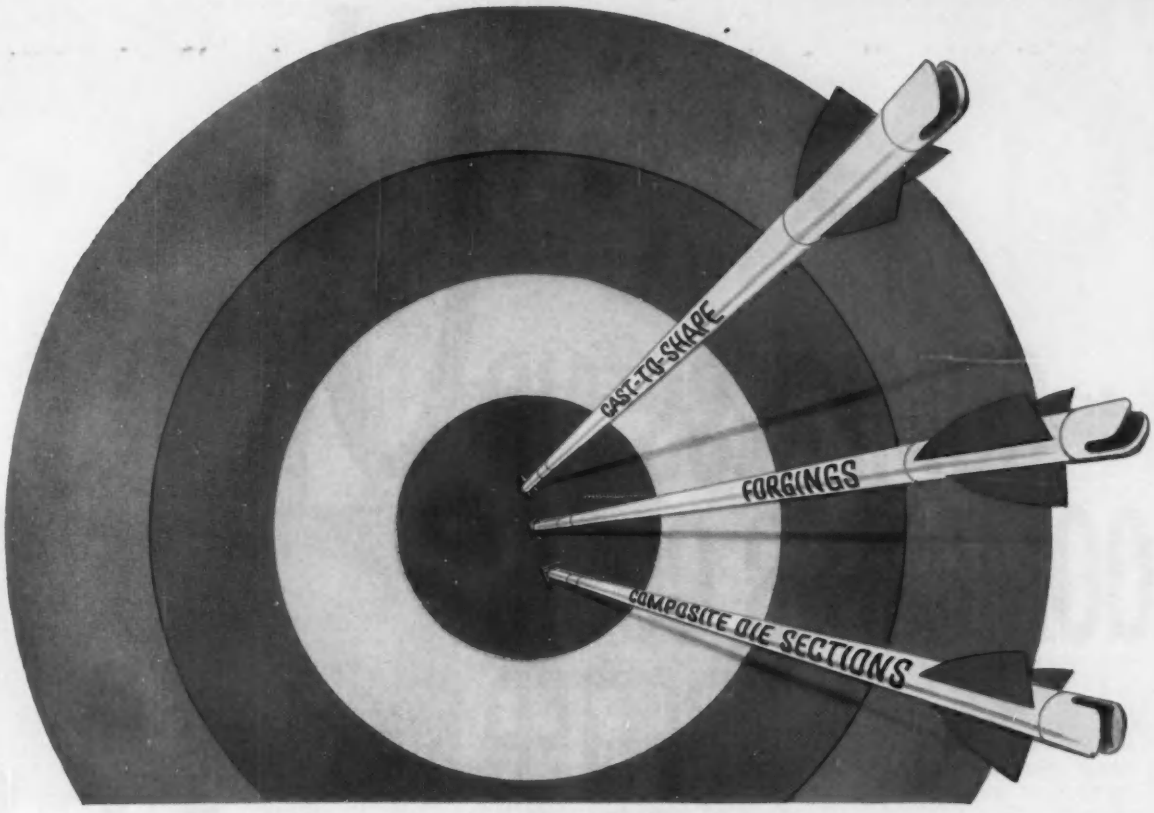
Both mills are Rollway Bearing-equipped, as are J & L's Stretch Reducing Mill and Electric Weld Tube Mill, installed at the same time.

Operations like these demand component reliability. Dependable Rollway Bearings regularly provide it. You can choose from a complete selection of sizes and types with maximum capacities. Consult Rollway's nearest Engineering Office to select the bearing just right for your job. Or start by writing for Product Line Catalog PL-559. Rollway Bearing Co., Inc., Syracuse, N.Y.

You can depend on

ROLLWAY®
BEARINGS
Radial and Thrust Cylindrical Roller Bearings

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • LosAngeles • SanFrancisco



A-L's F&C Division

Always on Target for Tool Steel Specialties

For tool steel in the exact form you need, in the most economical shape for your job—rely on the championship performance of Allegheny Ludlum's Forging and Casting Division. It will help you select the right material for bull's-eye performance every time.

Because A-L's F&C Division is the only plant in the U. S. to supply tool steel in cast-to-shape form *and* in forgings *and* in composite die sections, it can give you completely unbiased recommendations. Your A-L representative is never under any pressure to promote parts made by one process against parts made by another. His only concern is to help you select the best possible and most economical methods.

You get more than one-stop tool steel service from A-L. You get stand-out quality in each part:

√ **A-L's Cast-To-Shape** tool steels are melted in electric furnaces to precise laboratory standards. Exacting foundry practice enables F&C Division to make even very intricate shapes so that little stock need be removed for finish.

√ **A-L's Composite Die Sections** are made of fine A-L tool steel cutting edges electrically butt welded by a special process to nonhardenable steel bases. A wide range of straight and shaped sections is available in a huge array of sizes for any trimming, blanking, and beading die application.

√ **A-L's Smooth Hammered Forgings** come in an extensive range of shapes and in sizes up to 3,000 pounds. You can be sure of quick delivery because all A-L tool steel forgings are made from stocks of over 2½ million pounds of genuine A-L billets stored right on the premises.

For complete information on A-L's tool steel specialties, ask your A-L representative for a copy of the 28-page booklet FC4, or write: ***Forging and Casting Division, Allegheny Ludlum Steel Corporation, Ferndale, Detroit 20, Michigan. Address Dept. SA-11.***

ALLEGHENY LUDLUM
FORGING AND CASTING DIVISION

3280

COMPRESS AIR COMPRESS COSTS BETTER

when you design-in C/R Sirvon Piston Rings*

Here's how well they're working now—for others:

Case 1—In air: Two split Sirvon rings in one groove were used in a small portable compressor under these conditions: speed 1725 rpm, stroke .352", pressure 75 p.s.i., output air temperature 100°F. No lubricant. After discontinuance of testing at 2000 hours, the rings were still in excellent condition, functioning perfectly. Other applications require only a single ring.

Case 2—In oil: A leading farm equipment manufacturer has tested and approved C/R Sirvon solid rings for a hydraulic application at pressures up to 2000 p.s.i., and shock pressures to 2500 p.s.i. in fluid equivalent to S.A.E. #10 oil. (Rings have been applied in special cases under pressures up to 8000 p.s.i.)

Consider these advantages

Right now Sirvon rings are permitting important cumulative economies in pneumatic and hydraulic units for both manufacturer and user.

1. Sirvon rings can run bone-dry where oil might contaminate the system.
2. Friction loss is greatly reduced by the low coefficient of the base resins.
3. Low-friction Sirvon rings greatly increase service life — eliminate cylinder scoring.
4. Piston design is simpler, less costly.
5. Ring installation is simple, assembly costs less.
6. Leakage is reduced.

Further, Sirvon rings are practicable for use in almost any air, gas, or fluid medium. They are inert to all commercial chemicals except hydrofluoric acid and molten alkalies, and will operate at temperatures from −400 to +500°F.

Why C/R Sirvon Piston Rings?

Because Chicago Rawhide is already an acknowledged leader in the field. C/R has experience in the complex technology required for compounding, molding or extruding piston rings with correct thermal stability, wear resistance and dimensional accuracy. In short, C/R knows how—now—and is producing dependable rings in large quantities for major users. C/R Sirvon engineers will welcome the opportunity to work with you.

Free sample: Tell us the size ring you would like to see. We'll send you a free sample Sirvon ring in that range. No obligation, of course.

**"SIRVON" C/R's trade name for fluorocarbon resin based compounds. In this case the base was "Teflon" (Du Pont Registered T. M.)*

C/R

CHICAGO RAWHIDE MANUFACTURING COMPANY

1243 Elston Avenue • Chicago 22, Illinois

Offices in principal cities

See your telephone directory

In Canada: Chicago Rawhide Products Canada Ltd., Brantford, Ontario

Export Sales: Geon International Corp., Great Neck, New York

For Sake of Argument

What a Consultant Needs . . .

A GOOD CONSULTANT is one part knowledge, one part awareness, and two parts widsom.

Too many consultants put too much reliance on KNOWING more than their clients. Some of the best begin every new job by finding out exactly what the client already knows — and starting from there to get new facts.

Sound knowledge is essential to giving sound advice, but plenty of unsound advice has sprouted from correct facts. The good consultant never gets competitive (even in his own mind) about whether he or the client has the most information.

Of equal importance in successful consulting is AWARENESS . . . awarness of the people and actions which are creating the problem the client says he wants solved. Often, the consultant must sense that the problem presented isn't the real one at all. He may have to restate the problem and get it assigned to him in its true form. The consultant who lacks "awareness" often finds himself working on problems whose solutions bring meager results.

But WISDOM is the double-barreled ingredient that marks the truly successful consultant. Knowledge is merely knowing what things are. Wisdom is knowing what they mean — and what to do about them. Knowledge is only the beginning of wisdom.

Wisdom draws people to a consultant; attracts them to *ask* for advice. . . . And wisdom leads a consultant to listen before he reacts; to divine the real problems which are obscured by the stated problems.

True, no consultant can achieve even minimum success without one part knowledge and one part awareness. But he's doomed to mediocrity without his two parts of wisdom.

Next month: "We're all consultants sometimes"

Norman G. Shidle

"Instincts In Action," a new book by Norman Shidle, includes more than 140 "For Sake of Argument" pieces selected from those printed between 1946 and 1961. . . . Published by SAE, it is now available for distribution and may be ordered by circling SP-222 on p. 6.

HIKES PAYLOAD!

HYDROVAC® vacuum power brakes by Bendix are specified more often than all other makes combined. They weigh less, permit up to several hundred pounds more payload—increase your profits. **DOUBLY SAFE** Hydrovac power braking systems provide maximum dependability with the built-in safety of manual braking in case of power failure. **CUT COSTS**—less to buy, operate and maintain.

MORE HYDROVAC VACUUM POWER BRAKES ARE IN USE THAN ALL OTHER MAKES

Bendix Automotive Products Division

THE Bendix CORPORATION

chips

from SAE meetings, members, and committees

FAILURE RATE of diesel electric traction motors is under 2%, Canadian figures show, with most railroads using a 300,000 miles basic overhaul period. Main generator basic overhaul is recommended at 600,000 miles, but many have been run twice this distance with a negligible failure rate.

THE B-58 BOMBER requires more than 1000 lb of structural adhesives in its construction . . . adhesives which have proven ability for metal-to-metal bonding.

WIND TUNNEL TEST TIME planned and/or conducted for the Dyna-Soar program, well exceeds that for such programs as the B-47, B-52, Bomarc, and X-15.

SOLAR CELLS SHOW ALARMING DAMAGE on exposure to high energy radiation. According to recent findings, an exposure of 10^{10} protons reduces solar cell output by 25% – and this may occur in only 10 days in the peak fields of the Van Allen belts. Thus excessive shielding is indicated for high-orbit satellites employing solar cells.

SOLAR CELLS WON'T BE PROVIDING POWER for ground stations in the foreseeable future. A 10 – kw generator suitable for a modern home power supply would occupy 900 sq ft and cost $2 million.

AIRFREIGHT materials handling operations of both the military and commercial air cargo carriers are undergoing an evolutionary transition toward mechanization. . . . Cargo consolidation is the foundation upon which mechanized systems are being developed.

APPROXIMATELY 40 POUNDS of adhesives are used in the manufacture of the Corvette.

Automobile Assembly Line Lingo

butterfly — The throttle blade of a carburetor.

cat's whiskers — A fuzzy sealing strip fastened to the door or body panels and inside trim panels which comes in contact with the glass and effects an air and water seal.

cluster — Dials and gages on instrument panel.

console — A supplementary build-up to hold some of the controls and accessories for the driver.

crash pad — Padded cover for metal instrument panel.

day light opening — Glass area of car.

REAR VIEW MIRRORS on the outside of automobiles can cost seven cents to take along on a 1000 mile trip. At 65 mph, the increased drag due to the mirror can reduce fuel economy by 0.05 mpg.

The penalty for toting a 42 in.-wide car top rack, filled with luggage to a 15 in. depth, is 3 mpg at 60 mph.

The Big Did Not "Overpower" the Small

THE SMALL MILITARY UTILITY ENGINE shown at the left continued to perform satisfactorily, even after such strenuous testing at Yuma Test Station — exposed to blowing sand from an Army tank and desert heat — as long as it received proper servicing and maintenance.

The Small Car is Starting an Engineering Revolution

THE MARKET PENETRATION of the small car is having a definite influence on the problems faced by automobile and parts designers. And it bids fair to have even more influence if — as some enthusiasts are predicting — sales of cars under 3000 lb and with less than 116-in. wheelbase come to exceed the sales of full-sized cars in 1962 (if sales of imports are included).

Many engineers and executives still find it hard to believe that the penetration of compacts in the United States market has been as great as it actually is already. Yet, here are some of the facts:

- In the 1957 model year, compact cars (including small foreign cars) accounted for only 4.1% of total car sales. (At this time small foreign cars were outselling American small cars by more than 2 to 1.) (See Table A.)
- In 1958, only two American-built compacts were available.
- Every new line of cars introduced in the U. S. since 1958 has been in the compact car range — under 3000 lb and 116-in. wheelbase.
- For the 1961 model year, compacts are expected to account for 39.4% of all U. S. new car sales. (Note that U. S. compacts are now outselling small foreign cars by a 4 to 1 margin.)
- Falcon sales are now 41% of Galaxie-Falcon sales. Corvair sales are 22% of Chevrolet-Corvair sales (and Monza is gaining faster than any other model). The Comet accounts for 65% of Mercury-Comet sales.
- Practically all car producers have recently introduced premium or sports models of their smaller cars — and these are proving very popular.
- The all-new cars to be introduced in 1962 — Ford Fairlane, Mercury Meteor[a] and Chevy II — are all in the smaller car classification.
- The 1962 model year will have, in all, 14 of these small U. S.-built cars in competition.

This small car revolution is also responsible for tremendous activity in the entire automobile industry. For example, this year the industry will offer the public over 400 different cars from which to choose. Fisher Body alone will be building 110 different body styles. During the past two years, the industry has designed, tested, tooled, and built 10 new engines. It has introduced five new transmissions, and made major engineering changes in several others.

Table A — Compact Car Sales

U. S. Compact Car Sales (Model Year)	U. S. Built Compacts, %	Imported Compacts, %	Total Compacts as % of U. S. Sales
1957	1.3	2.8	4.1
1958	3.2	7.1	10.3
1959	7.7	9.3	17.0
1960	23.6	8.4	32.0
1961	32.6	6.8	39.4

[a] Mercury Meteor wheelbase will be 116.5 in.; weight — less than 3000 lb.

1962 passenger-car

Walter G. Patton
Engineering Editor, SAE Journal

(Written at the request of and with the cooperation of the SAE Passenger Car Activity Committee and the SAE Body Activity Committee)

THE introduction and phenomenal success of the small car (see Box above) is presenting the industry with a variety of intriguing new problems. There has been a switch, for example, to integrated body-and-frame construction from the separate body and frame used on most cars of over 120-in. wheelbase. In addition, these cars require more protection against corrosion and they present some difficult sound-deadening problems. Even material requirements are different. For instance, the compacts, on the average, require only two-thirds as much steel and three-quarters as much rubber.

Although the rise of the compact, with its attendant engineering problems, appears to be the most significant present-day trend, there are other important developments taking place, such as:

- Increasing emphasis on reliability, which is sure to have great influence

Contents of Article

Engines 32

Transmissions and drivelines 37

Chassis and suspension systems 39

Electrical systems 41

Brakes 43

Tires 43

Air conditioning and miscellaneous accessories .. 44

Body engineering 45

The phenomenal success of the small car is leading to many engineering changes in the automobile industry. It has brought increased emphasis on weight reduction on both small and full-size cars. Improving reliability and designing to eliminate grease fittings have also become important objectives.

engineering trends

on the design, materials selection, and manufacture of cars — as well as on engineering administration and supplier relationships.

- Elimination of grease fittings on the front end of cars. (It is estimated that up to 50% of the 1962 cars will not require front end suspension lubrication for at least 30,000 miles.)
- Better organized efforts to eliminate unnecessary weight from vehicles —particularly in the case of the compact cars. Use of computers to back up the engineering arguments for weight elimination is increasing.
- More and more use of computers to "build" engines, suspensions, and even car bodies on paper before experimental cars are built. In fact, Detroit's top engineers consider that the computer will eventually revolutionize many engineering practices.

Recently, a convertible body was developed on the basis of computer computations. The torsional curves plotted from the computer data were remarkably close to the experimental body test results.

Computers are being used extensively to examine car areas that are either deficient or overdesigned. Theoretical changes can be checked quickly with the help of computers. A substantial saving in material may result from the use of computers, selecting the proper gage of steel being an example.

Body engineers are now making computations of most typical selections in advance of prototypes. Elimination of "long hand" methods of computation frees engineers for more important work on stress and other problems that might otherwise not be undertaken.

Engines . . .

Buick introduces first V-6. . . . Chevrolet has new V-8, 4-, and 6-cyl inline engines. . . . Ford introduces 221 cu in. engine. . . . Engine weights are coming down. . . . Aluminum engines continue in production, although no new ones are being introduced this year.

THE entrance of the small car has brought a rapid increase in the percentage of 6-cyl engines. (In 1956, 19.8% of the engines sold in this country were 6 cyl; for 1961 — just five years later — it is estimated that 45% of the engines produced will be 6 cyl.) The basic, long-established tendency toward more powerful engines continues, however, for both the smaller cars and for full-size passenger cars. Note, for instance, that most of the manufacturers who introduced so-called "economy engines" are now offering power packs of higher horsepower, and average displacement for small-car engines is substantially higher than it was even two years ago. In addition, quite a few of the engines for the higher-priced models will have increased power in 1962.

Table 1 shows the basic engine trends in this country for the past decade. Weighted averages based on production of different models show that, during the 1950–1961 interval, the following changes have occurred: Brake horsepower increased from 105.5 to 175.8. Average compression ratio is now 8.84/1, compared to 6.86/1 in 1950. Average displacement is 264.9, compared to 240.4 in 1950. Bhp per cu in. has increased from 0.439 in 1950 to 0.646 in 1961, based on recent estimates.

It will be seen that the 1961 averages have dropped considerably since the peak was reached in 1958. At that time, average brake horsepower was 227.3, average compression ratio was 9.24/1, and the displacement average was 311.0. Changes in these data reflect primarily the change in emphasis during the past three years from big cars to smaller ones.

No new aluminum engines wll be introduced this year, but, contrary to earlier predictions, each of the aluminum engines introduced a year ago is being continued in production. Latest available reports indicate there may be a substantial increase in the total number of aluminum engines produced in 1962. This prediction assumes, of course, that the industry, generally, will have a good year. The strong trend toward the use of die-cast engine components made of aluminum continues.

The industry's engineers will be watching with great interest the cast-iron V-6 engine introduced by Buick this year. It will be machined on a separate line at the Flint, Mich., plant. This is believed to be the first V-6 passenger-car engine to be built in this country.

It is generally conceded that, up to now, all aluminum engines have carried a cost penalty. A convenient engine weight penalty figure for a 6-cyl cast-iron block is 70 lb. The complete new Ford 221 cu in. cast-iron V-8 engine weighs 460 lb; the new Buick V-8 aluminum engine weighs 324 lb. Generally speaking, engineers must balance the weight penalty of cast iron against the cost penalty of aluminum.

Up to now, sand-cast aluminum engines have carried a cost penalty. So have die-cast engines. Performance of aluminum engines in 1961 is excellent, engineers agree.

Ford and others have an excellent record of reducing the weight of cast-iron passenger-car engines. Using new foundry techniques, all of the car manufacturers are reducing wall thicknesses and, thereby lowering weight. It is probably true that, prior to redesign, some engines carried more excess weight than others. A frustrating problem for engineers nowadays is not to have foundry equipment available to take advantage of new foundry techniques.

The Buick 90-deg cast-iron V-6 engine will be available in the Special only. More rigidity than a conventional in-line 6 is claimed for the new design. A short crankshaft minimizes crank roughness and engine vibration. With 6 cylinders, the bore has been increased to 3.625 in. and stroke to 3.2 in., giving a displacement of 198 cu in. Otherwise, the V-6 is quite similar to the 215 cu in. aluminum V-8. Compression ratio is 8.8/1.

The V-6 engine is 140–180 lb lighter than are current comparable in-line 6-cyl units. A substantial power gain in the 25–80-mph speed range is reported. Engine firing sequence varies from bank to bank. Short, symmetrical manifolding provides good fuel distribution. There is a big gain in package size.

Oil pump body of the Buick V-8 cast-iron engine is aluminum. During the past nine years, a weight saving of more than 25 lb has been accomplished at Buick by using aluminum die castings. Reduced wall thickness has cut the weight of the 401 cu in. Buick cast-iron engine to 638 lb. This brings Buick engine weight per cubic inch to a very low level for engines of similar displacement. A single exhaust system is standard on all regular size Buicks. The exhaust system has been redesigned to reduce restriction on gas flow.

Buick LeSabre will have a 401 cu in. engine with a 2-barrel carburetor. This engine is rated at 280 hp at 4400 rpm, compared with 250 hp for the 364 cu in. engine. Increased displacement and freer breathing are responsible for the increase. The 2-barrel carburetor has larger venturis. Intake manifold has a larger cross-section. The 401 cu in. engine has a redesigned water pump, fan pulley, and fan spacer. The fan pulley offset has been reduced. The camshaft is also new.

There are no major changes in the Cadillac engines. Tolerances have been reduced, particularly on bearings. There is more selective fitting of engine components. The exhaust system hangers have been redesigned to reduce vibration and noise. A new single exhaust system is tuned to isolate vibration and noise.

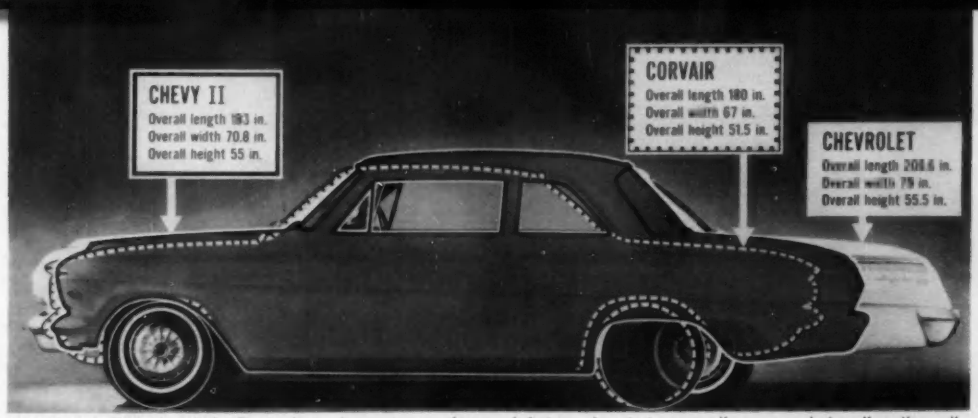
Chevrolet has a new 327 cu in. V-8 engine. (The Chevrolet 348 cu in. V-8 is discontinued.) Two 409 cu in. engines are available as options. The 6-cyl 235 cu in. and the 283 cu in. V-8 engines are standard.

The carburetion air filtration of the

Table 1 — Characteristics of U. S. Passenger-Car Engines
(Weighted averages based on per cent production of each model)

	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961[a]
Brake Horsepower	105.5	107.8	113.7	120.6	134.9	168.3	195.6	218.1	227.3	214.2	188.2	175.8
Compression Ratio	6.86	6.90	7.04	7.34	7.52	7.92	8.49	8.98	9.24	9.06	8.91	8.84
Bmep	121.8	122.8	126.0	128.8	131.9	140.7	147.5	151.8	153.8	150.5	148.9	146.6
Displacement	240.4	240.9	242.5	246.8	251.3	270.9	286.6	300.4	311.0	304.2	275.9	264.9
Bhp/Cu In.	0.439	0.447	0.467	0.486	0.533	0.616	0.677	0.710	0.725	0.690	0.661	0.646

[a] Based on estimated percentage of production for each model.



WHAT IS A SMALL CAR? The industry has not agreed on a definition, but it is generally accepted that "small cars" weight less than 3000 lb and have a wheelbase of less than 116 in. Overall length, width, and height for Chevrolet Corvair, Chevy II, and full-size Chevrolet are shown here. Ford Fairlane and Mercury Meteor are somewhat larger than Chevy II, but smaller than full-size Chevrolet.

6-cyl engine has been improved by a new concentric-type filter employing an oil-wetting polyurethane filter. The automatic choke for the 283 cu in. V-8 has been improved by supplying filtered air to the manifold heat tube.

The new 327 cu. in. V-8 engine has a larger bore and longer stroke than the 283 cu in. engine. Compression ratio is 10.5/1. The crankshaft is larger and more rigid. More cooling is provided around the spark plugs. There is a new cast-iron inlet manifold. New, heavier cast-aluminum pistons are specified as well as a 4-barrel carburetor.

There are two engines for the Chevy II: a 4-cyl 153 cu in. engine and a 6-cyl 194 cu in. engine (Table 2). Simplicity of design, ease of maintenance, and ease of production are features of the new design.

Bore and stroke of the Chevrolet L-4 are 3.875 and 3.250. Bore and stroke of the L-6 are 3.5625 and 3.250.

There are seven bulkheads on the L-6 engine and five on the L-4. . A forged crankshaft is used as well as hydraulic valve lifters. The engine has full pressure lubrication. The L-4 has a manual choke; the L-6 has an automatic choke.

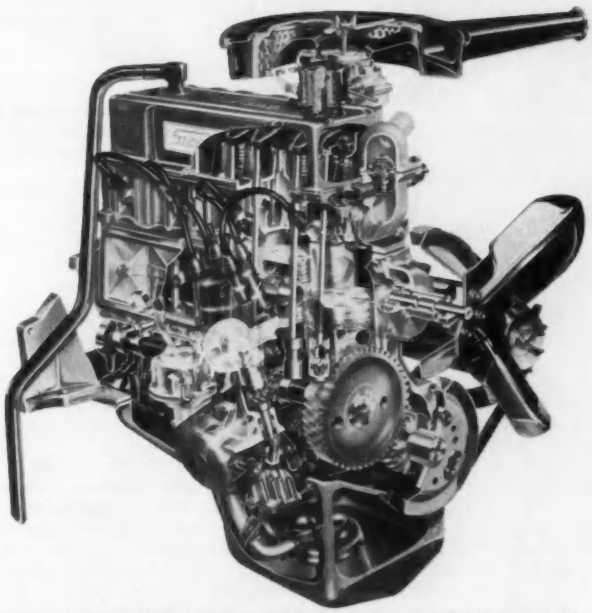
Probably the most important design feature of the 1962 Chevrolet engines is interchangeability of components. Table 3 lists some of the many items that are interchangeable.

Clutch housing, water outlet, distributor body and pistons are aluminum.

The Chevrolet Corvair 145 cu in. engine is being continued. Refinements since last year include new radial fin cooling blower and a new carburetor with automatic choke. A lag-free control quickly opens the choke when the engine is warmed up; the choke cannot then return until it is needed. A new combustion chamber provides additional power.

The 283 cu in. V-8 Corvette engine is replaced by the new 327 cu in. engine. High performance engines with special camshafts are again available. Fuel injection is also offered. A new domed piston permits 11.25/1 compression ratio.

The automatic choke system for



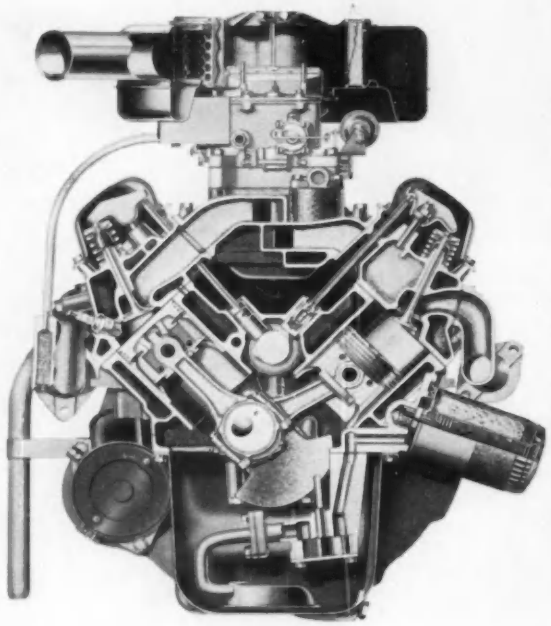
CHEVY II 153 CU IN. 4-CYL ENGINE illustrates simplicity of design and manufacture. This engine has many parts interchangeable with 6-cyl version, and also some with standard Chevrolet engines.

Table 2 — Engine Ratings — New versus Old

Engine	Displacement, cu in.	Hp	Rpm	Weight, lb
L-4 (new)	153	90	4000	360
L-6 (new)	194	120	4400	450
Standard 6 (old)	235	135	4000	608

Table 3 — Interchangeability of Components

Component	Engines
Valve train, valve lifter, push-rods	283, L-4, L-6
Valve, valve spring, and piston pin	283, L-4, L-6
Rocker arm and valve pivot	283, L-4, L-6
Pistons	283, L-4
Bearings — main and connecting rod	283, L-4, L-6
Cylinder spacing	L-4, L-6
Piston rings	283, L-4
Main bearing caps (1)	283, L-4, L-6
Oil shields, valve spring, oil shield, cap, and keys	283, L-4, L-6
Aluminum clutch housing	L-4, L-6



IT IS ONLY A COINCIDENCE that this year Ford will introduce a new 221 cu in. engine — the Ford Fairlane V-8 shown at left. Just 30 years earlier, Ford built its first V-8 engine, also of 221 cu in. displacement. Comparison of these two engines offers a comparatively rare opportunity to measure automotive engineering progress over a 30-year period:

	1932 — 221 cu in. For V-8	1962 — 221 cu in. For V-8 Fairlane
Valve Arrangement	L	O.H.V.
Bore and Stroke, in.	3.062 x 3.750	3.50 x 2.87
Piston Displacement, cu in.	221	221
Compression Ratio	5.5/1	8.7/1
Max Brake Hp	65 at 3400 rpm	143 at 4500 rpm
Max Torque	114 at 1000 rpm	217 at 2200 rpm
Fuel	Regular	Regular
Transmission and Axle Ratio		
3-Speed, Manual	4.11/1	3.25/1
2-Speed, Automatic	Not available	3.00/1
Overdrive	Not available	3.50/1
Engine and Transmission Weight, lb	615	460

Chrysler and Imperial has been modified to ensure choke closing when the throttle is opened prior to starting. A new fan provides higher rate of airflow. A single system muffler has improved tuning.

The standard Dodge Dart engines have 225 and 318 cu in. displacement. The Dodge Polara uses a 361 cu in. high-performance V-8. Ram induction is not available this year. A cable-operated throttle is specified. A new camshaft reduces valve gear noise. A 15-micron filter protects against carburetor flooding and engine stalling.

A 144 cu in. six and a 170 cu in. six are available for the Falcon. The torsional vibration damper has a rubber ring between the inner and outer sections of the crankshaft pulley. A 30,000-mile fuel filter change is recommended.

Refinements include deeper grooves for rings, increased piston-to-bore clearance, new steel struts, and tin-plated compression rings. There is a new starter with a sealed housing. The carburetor is new. Recommended extended-life antifreeze is ethylene glycol with an inhibitor added.

The new 221 cu in. Ford Fairlane V-8 is an alloy cast-iron lightweight (460 lb) engine with wedge-type combustion chamber and overhead valves. An exhaust-heated induction system is used and the new engine has a hydraulic constant-lash valve train. A 6000-mile oil change period is recommended.

New Ford foundry techniques have made possible recent substantial savings in weight. Wall thickness is reduced to 3/32 in. in some engine block areas.

Intake valves are Cr-Mn-Ni alloy; austentic alloy exhaust valves are specified. The engine has hydraulic tappets and a new high torque camshaft.

The new Ford crankshaft has five main bearings and a bolted-on sheet metal crankshaft pulley. There is no counterweight at the middle main bearing. The pulley and flywheel are counterweighted. A 2-barrel carburetor and paper-type, disposable fuel filter are specified.

The water-warmed aluminum carburetor spacer for the Ford Galaxie V-8 engine is located between the manifold and the carburetor. Elimination of the exhaust heat riser valve provides pulse heat in the cross-over in place of continuous flow. This reduces the exhaust system back pressure and levels out the heat supplied for gasoline vaporization. Miscellaneous improvements include rust preventive coating on valves, select fitting of both intake and exhaust valves, and laminated muffler inlet pipes.

The Ford Thunderbird engine has a new induction system featuring an easier breathing intake manifold, which admits a more uniform fuel-air mixture to all cylinders. The exhaust heat riser valve has been eliminated.

A water-heated control for the automatic choke on the Lincoln Continental eliminates excessive engine idle speed during short trips, tailors engine fuel enrichment requirements to the intake manifold mixture temperature, and eliminates choke enrichment at high altitudes. The carburetor corrosion-resistant linkage and die-cast aluminum body have a special protective coating.

The Lincoln exhaust system is fully aluminized. New heavy-duty flanges have been added this year. The exhaust pipe flange for the ball-joint connection is heavier. An aluminized coating has been applied to the dual mufflers, resonators, and to the laminated exhaust pipes.

Rear engine mount for the Comet incorporates a 3-leaf steel spring, dual rubber insulator, and a bracket for attaching the unit to an underbody crossmember. Other refinements include new, fast idle cam, and a new crankshaft with a torsional vibration damper. The carburetor has a Viton plastic float needle valve seat, a new pump, and it is especially designed to handle vapor as well as liquid fuel.

Improved lubricants and the full-flow oil filter for the Mercury Monterey engine also permit a 6000-mile oil change cycle. A new fuel filter with replaceable element permits normal service of 30,000 miles. The replaceable filter eliminates the sediment bowl.

The Monterey V-8 engine has a new float chamber needle valve assembly for the carburetor. The Viton plastic seat is less subject to clogging by dirt particles. Plastic bushings for the throttle plate last the life of the car. Permanent antifreeze lasts 30,000 miles

or two years and protects to – 35 F.

Mercury's major advance is the 223 cu in. 6-cyl engine. A new rotor-type oil pump is specified.

Compression ratio of the 292 cu in. Mercury V-8 is 8.8/1. The 2-barrel carburetor has a booster venturi inside of two large venturis to increase vacuum at slow speeds.

A new feature of the 352 cu in. Mercury V-8 engine and the 390 cu in. engine is combining water heating and exhaust heating of the incoming fuel-air mixture. This eliminates the exhaust cross-over valve and provides more even temperature of the incoming air-fuel mixture and rapid warmup. New insulation isolates the intake manifold from the push-rod chamber in the engine valley. The isolation barrier consists of a 1-in. deep, sealed-off air space provided by a steel plate covering the entire underside of the intake manifold.

The Oldsmobile 280-, 330-, and 345-hp engine have new pistons, which are slightly dished. Engine breathing is also improved.

Most important Oldsmobile engine change is the redesigned combustion chamber. The new shape permits an increase in compression ratio from 8.75 in 1961 to 10.25/1 on the 1962 model 280-hp engine. The improvement in efficiency (and an axle ratio change) is said to more than offset a 4¢ penalty for premium gas. The three center main crankshaft bearings on Rocket, Skyrocket, and Starfire engines have been lengthened ¼ in. Olds will continue to use a 2-barrel carburetor on the 88; 4-barrel on the Super 88 and Starfire.

Standard for Plymouth is a 225 cu in. six and a 318 cu in. V-8. A 361 cu in. engine with special camshaft and 4-barrel carburetor is also available. The 383 cu in. SonoRamic engine is not available this year.

An interesting innovation is a throttle linkage consisting of a flexible, sheathed cable running from the accelerator pedal to the carburetor. This replaces a mechanical linkage. Advantages claimed for the new design include elimination of feedback of noise and vibration, ease and smoothness of operation, and freedom from lubrication. The core is precision-drawn stainless-steel wire. The core slides in a flexible steel sheath lined with a self-lubricating plastic.

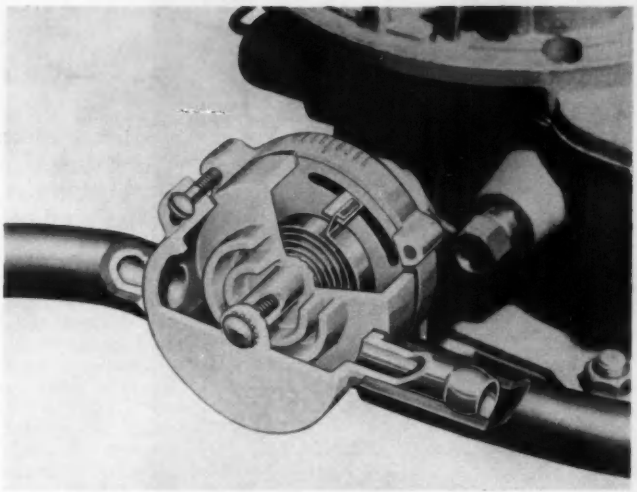
A new Plymouth engine mounting system has been designed for both the six and the V-8. A new camshaft makes the 8-cyl engine quieter. Valve opening and closing characteristics have been modified for quieter operation and smoother idling. There is additional protection against flooding and engine stalling. Engine oil requirements have been reduced from 5 to 4 qt on some engines. "Ventilated" contact points are used as well as a reduction-gear starting motor.

The Pontiac Tempest has a new forward engine mounting. The clutch release bearing has been revised. The new intake manifold is designed for optional 4-barrel carburetor, 4-cyl engines. The new manifold has streamlined, parallel runners that improve engine breathing. Provisions for rapid warmup have been included; manifold weight has been reduced 24%. The carburetor has been rotated 90 deg. The new engine for regular fuel was developed for use with an automatic transmission. The rating of this engine has been increased from 110 to 115 hp.

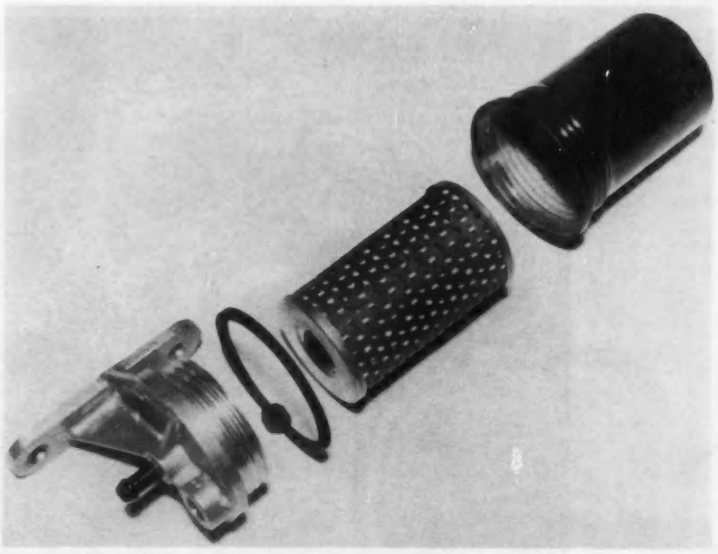
New intake manifold on the Tempest engine provides faster warmup. Manifolds feature larger exhaust heated area with special flow diverters that are designed to increase the heating efficiency of the exhaust gas.

New single-barrel carburetors for the Tempest Synchromesh and automatic transmission-4-cyl engine combination have been recalibrated to take advantage of the improved intake manifold. The new calibration gives improved level-road economy and fuel savings resulting from shortened warmup period. The air cleaner inlet tube has been enlarged. Accelerator linkage is redesigned and repositioned.

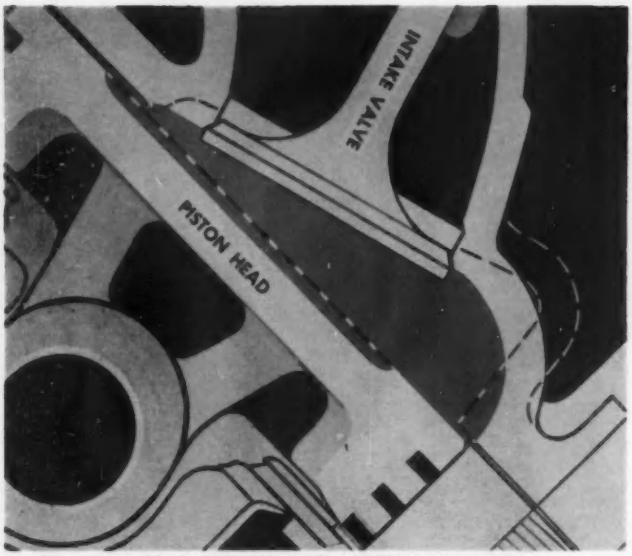
A new intake manifold on the Pontiac standard engine also permits faster warmup. Heat transfer fins are used and the exhaust heated area is larger. Operating economy is improved during warmup as a result of shorter "choke-on" period. A new



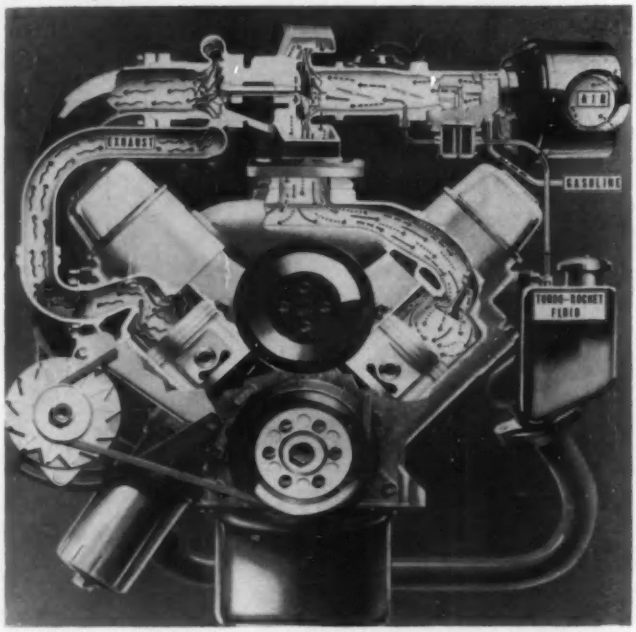
LINCOLN CONTINENTAL AUTOMATIC CHOKE has a water-heated control, which eliminates excessive engine idle speed on short trips and tailors engine fuel enrichment requirements to intake manifold mixture temperature.



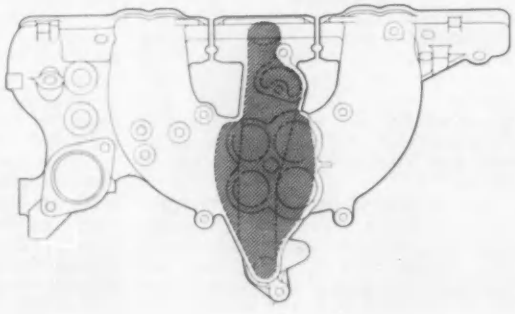
MERCURY FUEL FILTER does not require replacement of element until car has been driven 30,000 miles.



OLDSMOBILE COMBUSTION-CHAMBER "ROOF" has been lowered and contoured more smoothly. (Dotted lines show shape of 1961 chamber.) Note that top of new piston is dished slightly.



OLDSMOBILE ALUMINUM V-8 ENGINE has new turbocharger and fuel injection. Dotted arrows show flow of fuel-air mixture; solid arrows show path of injection fluid; curved arrows show flow of exhaust gas, which drives turbocharger.



PONTIAC TEMPEST INTAKE MANIFOLD is newly designed for 4-cyl engine having 4-barrel carburetor. Manifold weight has been reduced by 24%; better engine breathing and improved engine warmup are claimed.

throttle linkage employs a cross-shaft to prevent engine movement from affecting the throttle position. Recommended oil drain from the crankcase is every 4000 miles under favorable conditions.

There will be two 6-cyl over-head-valve Rambler engines for the Classic 6 — one with cast-iron, one with die-cast-aluminum block. The aluminum engine will be standard on the Rambler 400. The Rambler Ambassador V-8 has a 327 cu in. engine. American offers the 90-hp L-head engine and the 125-hp over-head-valve engine.

The ceramic-coated muffler and tailpipe will be standard for 1962. The carburetor air cleaner has a larger cellulose-fiber element. The 6-cyl engine carburetor will have a rubber-tipped needle valve for Holley carburetors and a synthetic-rubberized seat for Carter carburetors. Dashpots have been added to the carburetors on some models. The aluminum block engine has new exhaust valves with undercut stems. The fuel pump filter on the 6-cyl engines has been changed from ceramic to 15-micron paper element.

The cooling system thermostat setting has been changed from 180 to 195 F for the American L-head and Ambassador V-8 engines. Rambler engine cooling systems will be filled with Dowgard antifreeze as an extra cost factory option. The guarantee is 24 months.

Normal engine drain period is extended from 2000 to 4000 miles. The cellulose fiber air cleaner element requires cleaning every 4000 miles and replacement every 25,000 miles.

An aluminum cylinder block is again available at extra cost on the Plymouth Valiant. This 225 cu in. die-cast powerplant weighs 45 lb less than the standard 170 cu in. cast-iron block. The aluminum engine has a longer stroke, a longer throw crankshaft, longer connecting rods and push-rods; otherwise, the engine is about the same as the standard cast-iron in-line engine. New engine mounts — of the 45-deg shear type — help to isolate vibration. Additional protection against carburetor flooding and consequent stalling has been added this year. There's a new 15-micron filter in the carburetor fuel line and a 40-micron screen in the gas tank. Fuel tank capacity is increased from 13 to 14 gal. The exhaust system is aluminized and tailpipes are 25% thicker.

Included in the new engine items offered this year by Studebaker-Packard are a new water pump assembly, new inlet manifold, new generator and voltage regulator, and a new type air cleaner and carburetor for the Lark. Aluminum rod bearings will be specified for the 6-cyl and 8-cyl engines instead of babbitt. A new rear-axle ratio has helped to improve performance. Compression ratio of the S-P 6-cyl engine has been reduced from 8.5/1 to 8.25/1. 8.5/1 is the standard ratio for the V-8.

Transmissions and drivelines . . .

Simplified, lightweight transmissions dominate 1962 designs. . . . American Motors, Chrysler, and Chevrolet have new lightweight automatics. . . . Rambler introduces a no-clutch, manual unit. . . . Ford's new interlock prevents shifting by mistake.

THE dominant trend in automatic transmissions today is to lighter weight, simplified design, and reduced manufacturing cost. Where automatic transmissions have not had a major redesign within the past few years to remove weight and to provide smoother shifts and more economy, these changes are being made, often without a public announcement.

This year, more than ever before, transmission cases are made of aluminum rather than cast iron. Finer gear teeth are sometimes specified. Noise level in most transmissions is being reduced.

Detailed engineering changes in transmissions and drivelines announced by car manufacturers are summarized below:

A new 3-speed, torque-converter-type automatic transmission is being offered by American Motors Corp. (built by Borg-Warner). The new unit is 60 lb lighter and more compact and is better matched to a 6-cyl engine. Hydraulic fluid capacity is reduced. Substantially improved fuel economy is reported. The present vacuum control system is replaced by a mechanical system.

The new "Thrift-O-Matic" transmission for Rambler operates in about the same manner as a manual transmission but without the use of the clutch pedal. The clutch has a conventional disc and pressure plate. The new clutch is simpler and thinner than a standard spring-loaded clutch, it is indicated.

Engine oil pressure and intake manifold vacuum are used to operate the clutch. Engine oil pressure performs this operation in response to engine speed and torque requirement. After starting engagement is completed, clutch pressure is controlled by the engine vacuum.

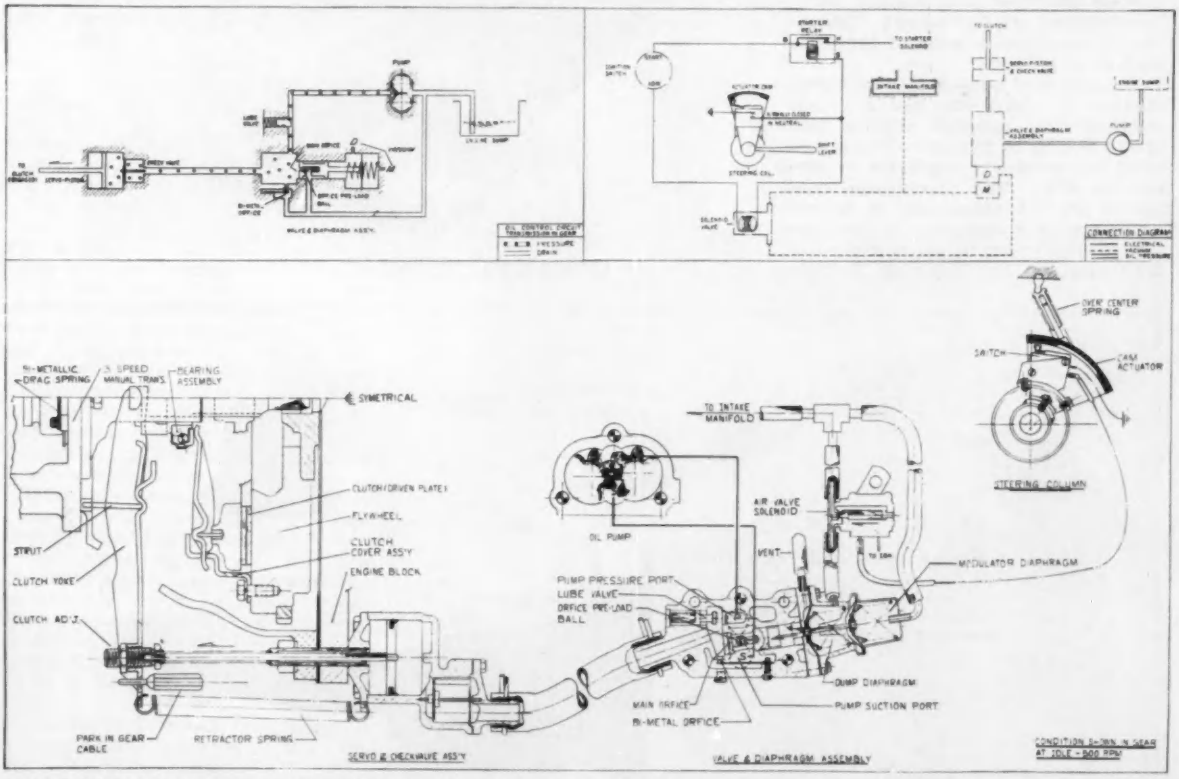
Initial movement of the shift lever releases the clutch. This puts servo pressure into the suction part of the pump. Completion of the shift reestablishes the clutch pressure.

The clutch operates automatically when moving the shift lever from neutral to or between any desired gear; also when downshifting. The accelerator pedal is released when shifting. Result is to eliminate the clutch pedal but not the clutch itself.

The torque tube drive on the Rambler Classic and Ambassador has been revised. A new 4-bolt trunnion joint is specified.

Chevrolet's new Powerglide replaces the Turboglide. This optional lightweight transmission is recommended for the 327 cu in. V-8 Chevrolet engine. It is a 2-speed, automatic unit with 3-element torque converter, having a compound planetary gearset and three interconnecting clutches. Gear ratio has been reduced from 1.82 to 1.75. The new unit incorporates features of Powerglide and the discontinued Turboglide. Lightweight has been achieved by extensive redesign, which includes an aluminum extension and a 1-piece aluminum case. The new unit is 35% lighter than the same transmission with 2-piece cast-iron case. The cast-iron case for a 4-speed Synchromesh Chevrolet transmission is being replaced by an aluminum case. Resulting weight reduction is 20%.

Chrysler's new, lightweight auto-



ENGINE OIL PRESSURE AND INTAKE MANIFOLD VACUUM operate clutch of this new American Motors semi-automatic transmission. Unit is shown in gear at idle — 500 rpm. Better economy and lower cost are claimed for new design, which eliminates clutch pedal, but permits hand shifting by driver.

matic transmission replaces the 3-speed TorqueFlite. Internal construction is new; the case is a 1-piece aluminum die casting, enclosing both the torque converter and the transmission. It is 60 lb lighter and has made possible a sizable reduction in the front floor hump. Despite its lighter weight, the new transmission is reported to have 10% greater torque capacity. Pushbutton operation is being continued.

The new manual transmission, used with 6-cyl Chrysler-built engines, has a new, low gear ratio: 2.95 instead of 2.71. The heavy-duty transmission with 2.55 low gear is standard for all V-8's this year.

Ford Fairlane's new rear axle uses a straddle-mounted pinion.

The 4-speed Hydra-Matic is being continued by Cadillac. Refinements in valving have produced smoother shifts. For 1962, the 3-joint driveline will be "custom fitted" to a particular chassis. Center bearing mounting at the rear of the transmission will be held to close tolerances so that misalignment is eliminated. A limited-slip differential has been added.

A new, pressure-compensated shift pattern is available on the Oldsmobile Hydra-Matic transmission. More precise valving permits smoother shifts. The shift pattern is synchronized more closely with engine torque, making possible smoother performance. Shift speed ranges are unchanged. Transition is smoother because of improved control of oil flow.

The standard 3-speed manual transmission for Ford cars has a clutch interlock that prevents shifting into low or reverse by mistake. The clutch must be completely depressed to permit the shift. The clutch pedal cannot be let out unless low or reverse gears are fully engaged. A mechanical throttle valve on Fordomatic has been replaced by a vacuum throttle control valve on the 1962 models.

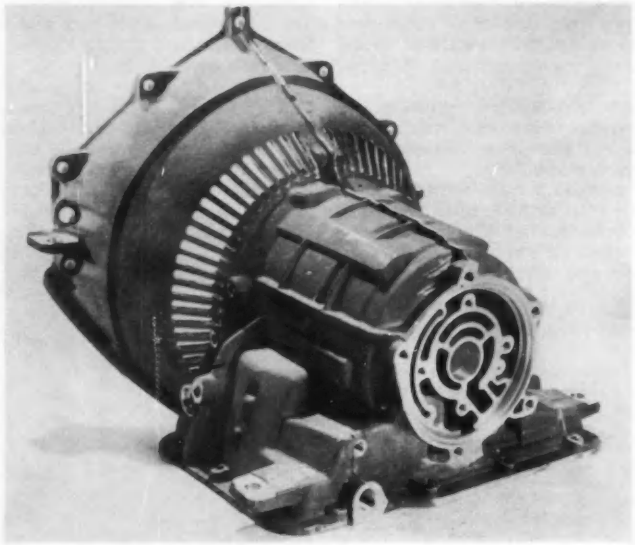
Buick's planetary gearset has been redesigned. Gear teeth are finer and the number of teeth in the pinion gears has been increased from 15 to 16. Turbine drive transmission for Buicks is unchanged.

Buick will offer a positive traction differential in the Special. This is virtually the same as the unit used by Buick on its standard cars. Buick Special will also offer a 4-speed Synchromesh transmission with a floor-mounted shift control.

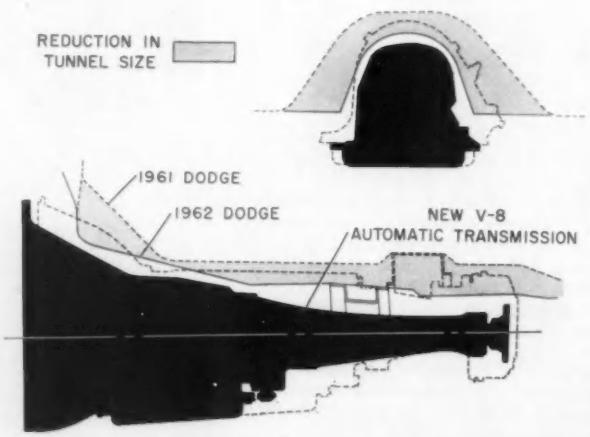
Pontiac Tempest's automatic transmission throttle linkage has been redesigned. The throtle valve control is also redesigned, using a flexible cable in a plastic lined steel tube. The new 4-speed manual transmission for the Tempest is synchronized in all forward speeds. New rubber-mounted propeller shaft damper bearings are used.

Pontiac's synchromesh transmission is now lubricated for life. Hydra-Matic fluid change is recommended at 25,000 miles. This year's valve body changes provide a smoother shift pattern, reduction of noise and vibration.

S-P Lark gear synchronization has been improved on both standard and overdrive transmissions. Automatic transmissions can now be equipped with an anticreep device. Lark axle ratios have been changed to give improved performance. A 4-speed transmission is optional on the Hawk.



AIRCOOLED BELL HOUSING for Chevy II transmission.



TRANSMISSION HUMP AND TUNNEL have been lowered and reduced in size in Dodge Dart and many other cars, as a result of transmission redesign and moving engine forward.

Chassis and suspension systems . . .

Elimination of grease fittings is a major development. . . . Chevrolet introduces single-leaf rear spring. . . . Widening the frame leads to reduction in Buick's front tunnel. . . . Chrysler has a new manual steering gear.

ELIMINATION of grease fittings has been going on steadily for many years. All car producers are eliminating grease fittings as rapidly as possible. A review of recent Ford developments in this area offers an interesting picture of what is happening.

The full-size Ford, Mercury, and Lincoln cars for 1961 had all remaining chassis grease fittings eliminated. The front joints were factory lubricated and sealed for a recommended period of 30,000 miles. In doing this, basic design of the Ford ball joints and steering linkage was unchanged. Lubrication has been eliminated by using lifetime seals made of new materials, combined with prepacking. Ford (and others) are using lithium-soap greases, impregnated with a solid-film, molybdenum disulfide additive.

Development of improved lubricacants, seals, and greases has paced this development. Joints sealed for 30,0000–35,000 miles are being offered practically across the board on the 1962 full-size cars.

Greases specified for this application must have these general characteristics: ability to withstand high pressures and prevent rusting of the spherical surfaces, high resistance to oxidation and absorption of contaminants, and high resistance to washing and absorption of water.

The second chassis change of outstanding engineering significance is the introduction by Chevrolet of a single-leaf rear spring.[1]

The suspension system for the new Chevy II features independent, high-mounted coil front springs and a single leaf spring at each rear wheel. Advantages of the single leaf spring include: uniform stress throughout its working length, elimination of inter-leaf friction, avoidance of stress concentration at axle mounts, and no metal-to-metal contact.

Maximum stress level of the new Chevrolet rear spring is 25% higher than the multileaf assembly.

The upper surface of the new Chevrolet rear spring — and only this surface — is controlled shot-peened. This is done *under tension* equivalent to several inches of jounce. Fatique properties are reported to be increased up to 10 times those of an unstressed spring.

The front Chevy II suspension is a conventional independent coil having a "high mounting."

The "Cruciform" type frame is being continued by Buick. Front section of the frame is widened substantially. This permits moving the powerplant forward 4 in. The wider frame makes possible a simplified exhaust system and lower front floor tunnel.

Front body mounting brackets for Buick have been moved outboard, permitting attachment to a more rigid portion of the body, out near the rocker panel section.

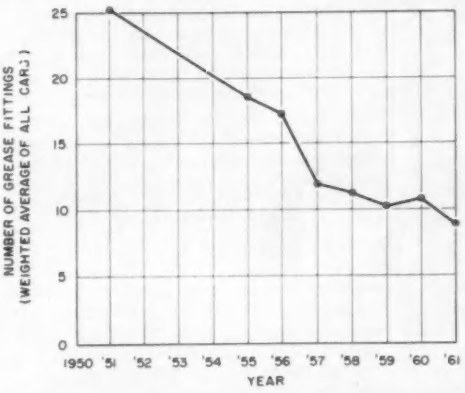
Torsional characteristics of the body-frame are improved. The Buick front cross-member has been stiffened. The rear upper control arm is now made of heavier stock. New variable-pitch, rear springs prevent coil contact at the end of the springs without having to lengthen the spring.

Coil springs are again used in the front and rear. Buick shock absorbers use all-weather fluid. Nylon sleeves on shock absorbed pistons help maintain the piston seal.

Cadillac bushings are more resilient. Spring rates have been changed wherever necessary to give improved ride, but there is no major change. A new frame cross-member replaces the previous design. Body mounts have been tuned for better isolation of vibration and noise.

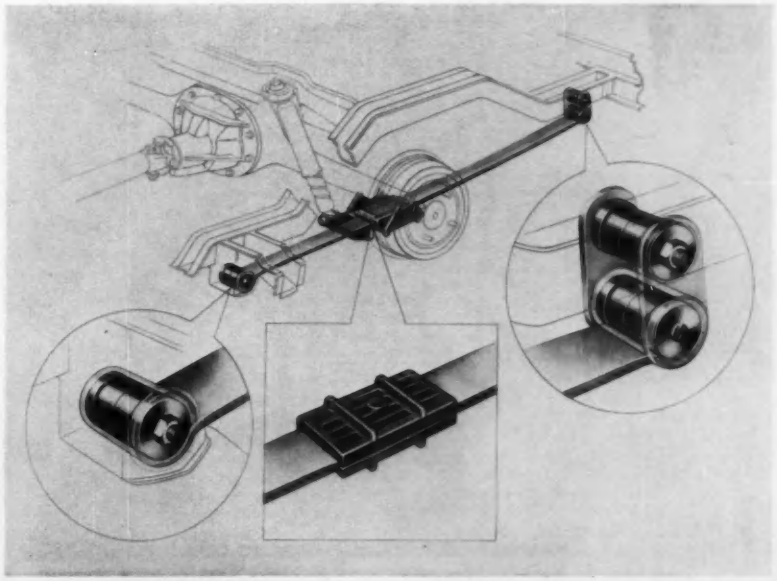
The rear Fairlane spring is attached to the torsional shackle in the front and a compression shackle in the rear. The front spring bracket is attached

[1] This development will be described in more detail in a paper to be presented at the SAE Annual Meeting, Detroit, January, 1962.



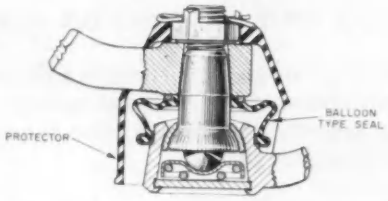
NUMBER OF GREASE FITTINGS PER CAR has steadily dropped during past 10 years. Since 1951, the average number has gone from 25 to less than 10.

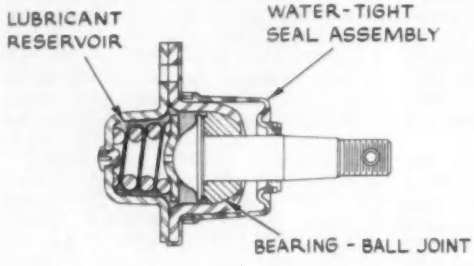
Courtesy, Check-Chart Corp.



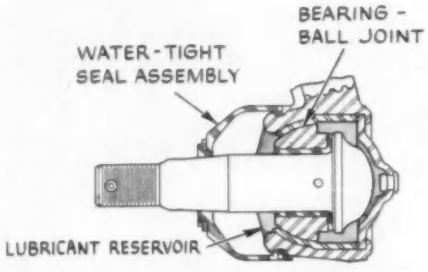
TAPERED SINGLE-LEAF SPRING installed at rear wheel of Chevy II. This is the first use on a U. S. production car of a development that has been under consideration for many years.

GREASE SEALS for front wheel ball joints and steering tie-rod ends on Dodge Dart and Lancer require minimum attention. Factory recommends ball joint relubrication after 32,000 miles. Tie-rod ends are sealed for life.



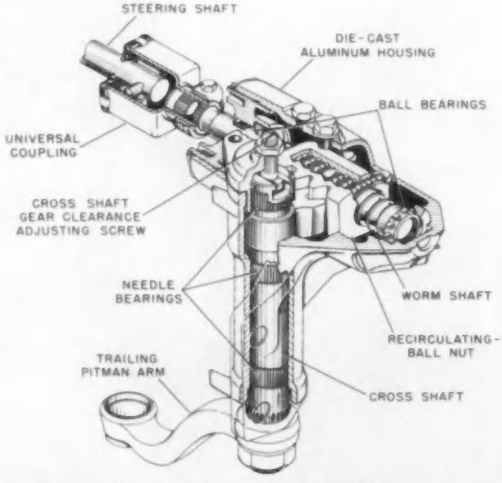


UPPER BALL JOINT ASSEMBLY



FACTORY-SEALED CHASSIS LUBRICATION FITTINGS are used exclusively on full-size Oldsmobile.

LOWER BALL JOINT ASSEMBLY



CHRYSLER CORP. MANUAL STEERING GEAR is lighter and fast steering. Needle bearings support cross-shaft and roller. Housing of unit is aluminum. Roller ball bearings contribute to low friction characteristics of new design.

to a torque box. An improved front wheel bearing adjusting nut permits finer adjustment for bearing end-play. Interval for repacking has been extended to 30,000 miles.

The Ford Falcon front stabilizer strut is 20% heavier. A rubber-insulator pad is installed above each front coil spring as a sound deadner.

Piston diameter in the new rear shock absorbers of Lincoln Continental has been increased from 1 3/16 to 1⅝ in. Hardened, chrome-plated shafts are now used in Lincoln Continental shock absorbers.

Chassis lubrication fittings have been removed by Chrysler on full-size cars from all points on front suspension ball joints, steering linkage connections, and clutch torque shaft bushings. These points are now prelubricated and sealed at the factory.

Balloon-type seals are made of molded neoprene rubber, reinforced by steel bands. The ball-joint seals have nylon inserts. Permanently lubricated tie-rods are protected at the outer ends by boots, which now enclose the seals.

In the standard full-size Oldsmobile, all front end lubrication points have been eliminated. Also, the need for lubrication of distributor and generator is eliminated. Molybdenum disulfide lubricant is specified for the ball joints.

A few years ago, Olds standard cars had 17 lube points; last year, the number was reduced to 4; this year, all have been eliminated. If lubrication is required, the plug is removed and an Alemite fitting is inserted. Principal change on this year's ball joints is improved external seals that keep out dirt and ensure longer life. A rubber guard or boot protects the joint housing.

Olds body mounts are improved. Springs have been softened. A change in shape of the rubber isolation mounts on the F-85 has made a substantial contribution toward a better ride.

Chassis lubrication has been eliminated by Plymouth from all points on front suspension ball joints, steering linkage connections, and clutch torque shaft bushings. These points are now prelubricated and sealed at the factory.

A new manual steering gear is available for all the Chrysler-built cars. New features include recirculating ball and a die-cast-aluminum housing. The gear is 7 lb lighter than last year. A new universal couple connects the

steering shaft to the manual gear.

The Plymouth steering system also provides greater isolation from road shocks. The mounting is more rigid. Steering shaft bearings are rubber insulated. There is a new universal coupling on the steering shaft.

Normal chassis lubrication interval after a standard car leaves the Pontiac factory is now 35,000 miles. New front suspension upper ball joints are used on full-size cars. The rear axle is lubricated for life.

Taper roller front wheel bearings are specified this year. Shock absorber valves have been changed to give a softer ride. Steering arms and tie-rods have been revised to permit smaller turning diameter and give improved steering geometry.

Upper ball joints of the Pontiac Tempest are new. Rear suspension geometry has been revised by tilting the rear-axle control arm pivot axis.

Front suspension for the Rambler Classic and Ambassador is completely redesigned. It has a single lower control arm with outer ball joints and a rear-facing radius rod. Front springs and shock absorbers are recalibrated. Caster and camber adjustment is provided on the upper control arm pivot bolts.

Steering linkage, idler arm, and pitman arm are new. Overall steering ratio is raised for the Classic 6 and lowered for the Ambassador V-8. Both are now 28.3/1. New ratios provide easier steering with less effort.

The Ambassador also has a front suspension sway-stabilizer torsion bar to compensate for added weight of V-8 engines. American overall steering ratio has been increased from 21.6/1 to 27.6/1 for manual steering. Rear springs and shock absorbers have been revised.

"Cushion-link" suspension again applies to all four wheels on Mercury Monterey. Cushioning permits all four wheels to recede to absorb very light shock loads such as tar strips. Spring-loaded lower ball joints have a conical spring and stamped steel seat, which presses against the spherical joint. This keeps the spherical part continually in contact with the seat.

A similar spring was used in the 1961 Monterey upper ball joints. For 1962 cups retaining the spring-loaded ball joints are made of 50% heavier steel and provide additional grease capacity. A 30,000-mile supply of molybdenum disulfide base lubricant is packed in suspension and steering linkage joints and sealed in at the factory. After 30,000 miles or two years, the nine sealed joints can be repacked. Front wheel bearings also have extended lubrication to 30,000 miles.

Two needle bearings are used on the sector shaft in the steering gear box.

S-P Larks have new front coil springs of higher capacity. Rear springs have been improved by the use of inserts at the tip end of the spring leaves, replacing full-length inserts.

Electrical systems . . .

Drive to improve reliability of electrical components gains momentum. . . . Chrysler introduces gear-reduction starter. . . . Use of nylon in electrical equipment is increasing. . . . Alternators get attention, but major breakthroughs are likely to come later.

AMONG a number of developments in automobile electrical components on the 1962 model cars deserving comment are the following:

- Reduced size and weight of components.
- Greater effort is being made to ensure reliable functioning of the part. There is more protection of the part in service. Ability to service electrical components has improved noticeably.
- Use of nylon in electrical components is increasing.
- Contrary to earlier reports, no new alternators have been announced for passenger cars not equipped with air conditioning.
- There have been some interesting lighting developments, including Cadillac's new "cornering lights" and the new Lincoln Continental turn signal that cancels quickly on shallow turns.

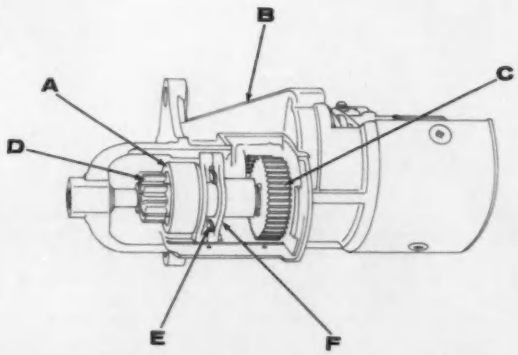
The list could go on to include Chrysler's new "ventilated contact" points, Lincoln Continental's red light flasher (when either rear door is not fully closed.) Electric windshield washers are gaining in popularity and the use of printed circuits is increasing.

Weight saving is a major objective for nearly every electrical component being designed today for the automobile industry. Chrysler's new reduction-gear starter is an excellent example. It is said to be quieter operating, and considerably smaller and lighter than the direct-drive starter used previously. A solenoid—shift feature prevents disengagement before the engine starts.

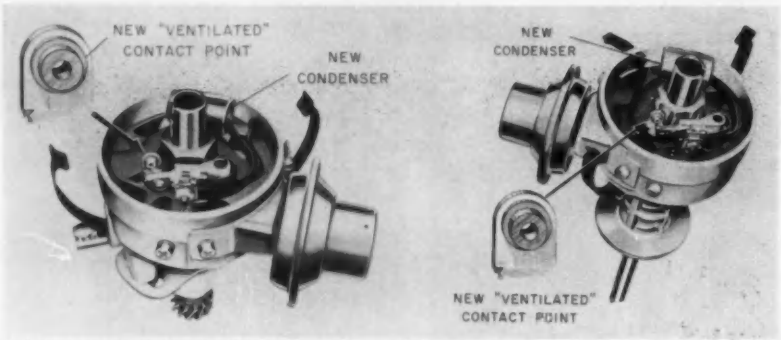
Operating advantages of the new starter include: greater starting torque at low cranking speeds and reduced current draw under heavy loads. Due to its reduction gearing, the motor runs much faster. Its high rotational inertia and improved torque characteristics are also said to improve hot starting. The new Chrysler starter weighs 15 lb. It has 15% fewer parts. The reduction gear set ratio is 3.5/1 between the armature and ring-gear drive pinion, providing a total ratio of 45/1 between the armature and the engine crankshaft.

Lincoln Continental has taken some exceptional steps to protect its electrical system. All Lincoln Continental instrument panel wiring is nylon coated. Wrapping protects the main wiring harness. All ignition wires are coated with hypalon. A special testing machine checks all electrical components and wiring. Power windows have 3-in. diameter motors, which are dipped in latex rubber to resist moisture.

Chrysler has made some important changes in its electrical system to make it simpler and more foolproof. For example, all electrical wiring inside the passenger compartment for the Chrysler and Imperial terminates in a single multicircuit connector



REDUCTION-GEAR STARTER for Chrysler Corp. cars is smaller and weighs 15 lb. Solenoid shifting device meshes reduction gears (C) via spring shifting fork (E) and nylon actuator (F). Solenoid assembly is energized when ignition switch is turned to "start." Solenoid plunger pivots shifting fork, which engages drive pinion (D) with ring gear. Motor cranks engine with 45/1 ratio between armature and engine crankshaft. Overrunning clutch (A) protects armature from overspeeding. B is one-piece solenoid, gear and pinion housing.



DODGE DISTRIBUTOR POINTS for both 6-cyl and 8-cyl engines are said to provide longer point life and reduced maintenance. Larger "ventilated" stationary point permits points to run cooler.

which snaps into the dash panel. Lights, ignition, accessories, and electrical system wiring is plugged into the connector from the engine compartment side. Checking of instrument panel circuits is facilitated. Additional fuses protect the Chrysler electrical circuits. The fuse block is located inside the glove compartment on the new Chrysler.

Failure of the Chrysler tail lamp circuit causes the instrument panel lighting to go out, warning the driver his tail lights have stopped functioning.

Chrysler's new "ventilated" contact points are larger in diameter. The stationary point has a hole in the center. Points are reported to run cooler and last longer, since electrical current is distributed more evenly around the annular contact area. A new distributor condenser provides more effective arc quenching. Nylon parts are used in the breaker point assembly of the distributor.

A separate fuse has been added to the Rambler dome light electrical circuit. All Rambler models will be equipped with special batteries designed to require water addition only three or four times per year. An all-transistor radio is offered.

Cadillac is introducing "cornering lights." When the lights are on and a turn is indicated, the light, mounted in the grille at the side of the car, comes on, right or left, illuminating the area in the direction of the turn.

Cadillac's daytime tail light represents a significant change from earlier designs. Daytime appearance shows a reflex red image in the center inside a white light background. When backing up, the backup light shows red in the top half only. Tail-, and/or stop-light position is center red with all four other positions, top and bottom, red.

Headlamp filament caps on Chrysler cars have been enlarged to eliminate stray downward rays, which would otherwise reflect from bumpers and other polished surfaces. The Chrysler stop-light switch is now mechanically operated, replacing a hydraulically operated switch.

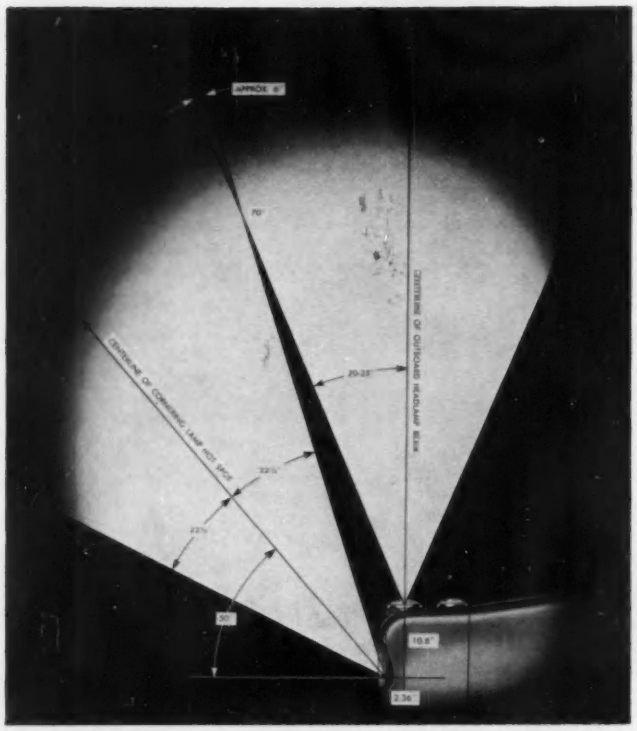
The Lincoln Continental turn signal now cancels on shallow turns or at about 55 deg. This assists on cancellation of signals on ramps in-and-out of expressways and on other shallow turns.

Plymouth is using a mechanically operated stop-light switch, replacing a pressure-operated switch. The instrument cluster is designed so it can be removed readily for bench servicing.

The Pontiac distributor has lifetime lubrication. New main wiring harness this year includes a number of accessory feed wires. Generator and voltage regulator are improved. Turn signals have increased intensity. The Catalina model windshield motor is now "burn-out" proof, even under prolonged stall conditions. Main wire harness is more accessible. A new hydraulic stop-light switch is now specified.

Mercury Monterey headlight circuits are protected by thermal automatic reset-type circuit breakers. A master fuse block, mounted behind the instrument panel on the light switch, can be easily removed. The ignition switch has its terminals buried inside the switch housing.

Up to eight circuits are included in a single multiple connector. Each connector interlocks only with its own mate. The new turn signal has a plastic switch body. Two-speed electric wipers are available at extra cost.



"AROUND THE CORNER LIGHTING" is feature of new Cadillac. "Cornering lights," mounted in grille on each side of car, go on when turn signal goes on. They light up an area that is not covered at all by outboard headlamp beam.

Brakes . . .

Cadillac and Rambler are first U. S. cars to use dual system hydraulic braking. . . . More self-adjusting brakes are used. . . . Chrysler has a new power brake. . . . More bonded lining specified.

FOR the past three or four years, Cadillac has introduced each year at least one significant improvement in its braking system. Cooling fins were added several years ago. For 1962, Cadillac is introducing a dual braking system.

Self-adjusting brakes appear to be gaining in popularity. There has been no public announcement up to this time of the adoption of disc brakes by any American car builder.

Cadillac and Rambler are the first U. S. passenger cars equipped with a dual braking system. Separate braking systems are provided for front and rear.

Cadillac's protective parking brake system (introduced in 1960) ensures availability of parking brake for emergency stops. Wheel cylinders are larger than last year; each cylinder provides its own braking power to two front or two rear brakes. The new Cadillac vacuum release system operates faster this year. A new brake drum backing plate prevents water leaking into the front drums, thus avoiding wet, inoperative brakes.

An all-new, tandem or dual master cylinder brake system (by Bendix) is offered as standard on all 1962 models by Rambler. The new dual brakes are self-adjusting.

Separate systems are provided for front and rear of the car. In case of a failure of the front system, the rear system continues to operate.

Power brakes on the larger Oldsmobile are now self-adjusting — accomplished by backing up the car.

The new Ford Fairlane brakes are self-adjusting — continuing a Ford brake policy started several years ago. A more stable lining is specified. Brakes are machined to closer tolerances. Chromium-plated brake shoe ledges are specified on some models.

Significant steps are being taken to assure the quality of brakes on the Lincoln Continental. After rough machining, brake drums are stress relieved for 1 hr at 900 F to relieve internal stress. This is followed by two finish cuts. Sedans have flared, cast-iron drums and convertibles have flared aluminum drums with cast-iron liners (on the front wheels only). Brakes are again self-adjusting. The brake shoe ledges are chromium-plated to resist wear and friction.

Chrysler has a new power brake. The new booster chamber, which contains dual diaphragms, is evacuated by engine vacuum. When the brake is applied, one side of each diaphragm is opened to atmosphere pressure. The resulting differential pressure on each diaphragm is transmitted to the master cylinder push-rod, which provides the power boost. (The booster chamber of the earlier Chrysler design was maintained at atmospheric pressure.)

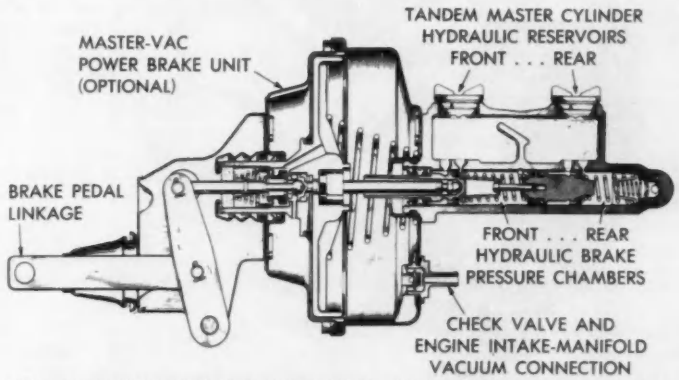
Servo-contact brakes, of the self-energizing type, are used on the Plymouth. The new brakes have unusually low pedal effort and generous pedal reserve. Excellent stability and effective water sealing are claimed for the new design. Brakes are adjusted automatically. Parking brakes are located on the rear wheels.

Dodge and Plymouth brakes are of the servo-contact, self-energizing type. Drums are 10 in. in diameter. Bonded linings are specified. The new system offers automatic adjustment.

Pontiac Tempest brake shoes have been strengthened by increasing the flange length.

Optional metallic brake linings are available on the new Chevy II. There are six sintered segments on the primary shoe and ten segments on the secondary shoe.

Aircooled, finned aluminum front brakes and continued on Buick. Finned drums are used all around. Slotted wheels and wheel covers permit maximum air flow.



TANDEM, MASTER CYLINDER HYDRAULIC BRAKING SYSTEM, designed by Bendix, is standard for all Ramblers. Power brakes are again optional.

Tires . . .

2-ply tires are specified on more U. S. passenger cars. . . . Will be used on most smaller cars. . . . Advantages include: lighter weight, better traction, and cooler operation at highway speeds.

TWO-PLY tires are replacing 4-ply tires on most of the smaller American cars. Claims for the new tires include better traction, improved skid resistance, cooler running, softer ride, and less rolling resistance.[1]

The new 2-ply tires are lighter and are reported to reduce unsprung weight 2–4 lb per car. Amount of rayon by weight is same as for 4-ply tires, since the denier of the cord used is greater. However, since there is only one ply surface instead of three, less rubber has to be used and less interply friction is developed. Lower internal friction, it is argued, promotes cooler running at highway speeds and reduces rolling resistance.

In 2-ply tire construction two sheets of large-diameter, rubberized rayon cord are laid criss-cross in the carcass (instead of 4-plys). The two layers are about equivalent in strength to 4-ply construction. However, the 2-ply tire has only three frictional surfaces. This, it is argued creates less heat, makes tires run cooler at turnpike speeds.

The 2-ply tire also has more flexible sidewalls.

The new tires provide some reduction in harshness and ride is said to be improved over rough pavement and tar strips. There is reported to be as much as 22% more tire tread on the road.

Two-ply tires will be used up to about 7.50 × 14 size. Larger size tires for 1962 model cars will, with few exceptions, feature the 4-ply construction and also narrow band white sidewalls.

Air conditioning and miscellaneous accessories . . .

Frigidaire 6-cyl opposed compressor is quieter and adds 25% to cooling capacity. . . . Chrysler offers new axial blower. . . . Cadillac's Cruise Control permits precision driving without using the accelerator pedal.

NEW General Motors' cars will feature an air conditioning system which includes a new, 6-cyl opposed compressor. The new unit is smaller, quieter, and freer from vibration than the previous designs. Cooling capacity is reported to be boosted up to 25%. Alternators are not used with the GM units, contrary to earlier predictions.

The new compressor design replaces five side-by-side, axially placed pistons with three axial, double-acting pistons.

Buick's new air conditioning installation also features a magnetic clutch and a new suction throttling valve to replace the former hot gas bypass valve.

Cadillac, Buick, Oldsmobile, Pontiac, and Chevrolet will offer the new 6-cyl opposed compressor.

Improved air distribution is reported by several car producers. In the Oldsmobile, for example, there are new grille openings; also, auxiliary outlets above the main side outlets inside the car. These provide a general flow of cool air in the area of the front seat occupants' faces. There is also improved air overall distribution by permitting division of air to front and back seats simultaneously.

Chrysler Corp. is offering a new air conditioner package having a higher cooling performance and improved distribution of cooling air. The new system combines heating and air conditioning functions in a single package. A larger, more powerful axial blower is more efficient, delivering up to 225 cfm of air. The refrigerator system is unchanged.

Instead of depending on ram air for cooling, the new Chrysler blower is used continuously. With the car stationary, ventilation is said to be better now than it was at 30 mph in 1961 models. At 30 mph, it is claimed, the added ram effect boosts the flow of cooling air up to 250 cfm.

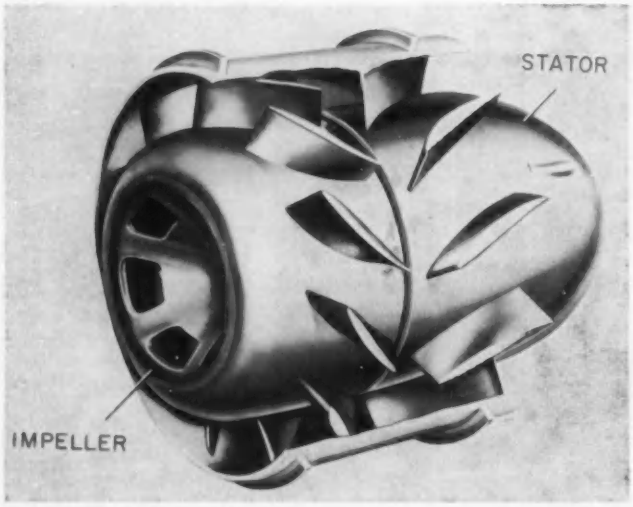
The new Chrysler axial-flow blower consists principally of a stator section with guide vanes to straighten the airflow, and a rotating impeller which pressurizes the air and discharges it at high velocity. Both the stator and impeller are magnesium die castings. An electric motor inside the stator hub drives the impeller.

Lincoln's new air conditioner compressor has a new oil pump and lubrication system. A shroud has been added for the thermostatically controlled engine fan in air conditioned cars.

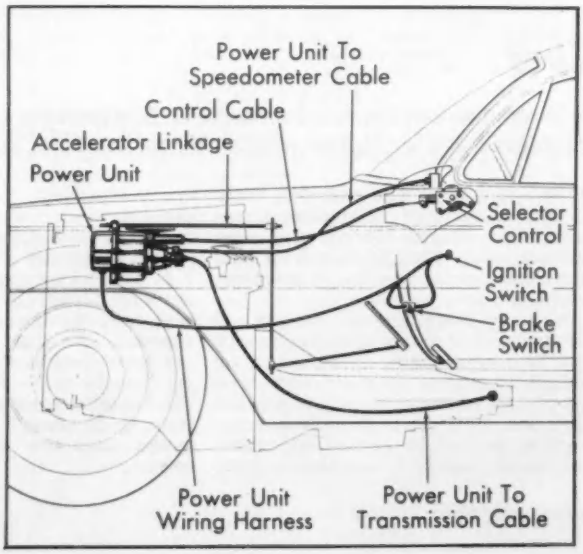
Cadillac will introduce the new Perfect Circle Cruise Control. This is a 3-in. diameter wheel, mounted within easy reach of the driver, which can be turned quickly to the exact speed range desired. Action is so smooth you can actually drive the car through traffic using only this control, according to Cadillac engineers.

Single-speed, parallel-action electric windshield wipers are specified by Cadillac. The new 15-in. blades wipe 760 sq in. or 63% of windshield area.

Available as extra cost accessories on the Lincoln Continental are remote control outside mirror, automatic headlamp dimmer, electric antenna, and vacuum-powered deck lid release.



CHRYSLER CORP. AXIAL-FLOW BLOWER consists principally of stator section with guide vanes to straighten airflow. Rotating impeller pressurizes air and discharges it at high flow rate (225 cfm).



PERFECT CIRCLE CRUISE CONTROL is being introduced on new Cadillac. A 3-in. diameter wheel, mounted within easy reach of driver, can be turned quickly to exact speed range desired.

Body engineering . . .

Using materials efficiently is the body engineer's No. 1 problem. . . . Car bodies are decreasing in size but the trend is mixed. . . . Protection against corrosion and sound deadening programs move ahead. . . . All cars will be equipped with seat belt anchors for front seat.

BODY engineers agree that the weight of a car is dominated by its size and, to a lesser extent, by materials selection. The average weight of U. S. cars has declined more than 400 lb since 1959, due primarily to the growing popularity of the small car. Up to now, the aluminum engine has contributed only a limited amount toward weight reduction. A few pounds of weight have been taken off by eliminating the wrap-around windshield. By making body stampings in one piece, and thus eliminating welds and by reducing the amount of body solder used, some savings in weight have been accomplished. Less spectacular but highly gratifying savings have been made by improved design.

The pay-off for better use of materials takes several forms: fewer pounds of material may be required and lower cost or lighter materials may be used. The customer benefits, of course, through improved fuel economy, better performance, and often lower first cost of the car.

Although the length of most cars is unchanged this year, Chrysler Corp. cars will be 7 in. shorter. By shortening and redesigning the body, Chrysler has also reduced weight by about 200 lb. Another 200 lb saving has been attained by the use of lighter materials for the transmission and by weight savings in the engine, transmission, steering gear, and other components.

As part of the design program, Chrysler Corp. cars will not have the cowl bolted on.

With respect to unitized versus body-and-frame construction, today's rule for engineers seems to be this: up to 120 in. wheelbase and 3200 lb, use unit construction, if the wheelbase is more than 120 in., use body-and-frame. This is the way the economics work out under today's conditions.

The introduction of more short-wheelbase cars has pushed unitized construction into the foreground: however, there has as yet been no appreciable change in the larger cars. If a new car of more than 120-in. wheelbase were introduced today, it would probably be body-and-frame construction, unless other factors (like assembly plant facilities or interchangeability of parts) ruled against this design.

There is increased use of shallower frames — to gain head and leg room.

Unitized designs seem to be changing constantly, primarily to gain space, add stiffness, and cut costs. It is often predicted that the industry will *tend* to go all one way, *if possible*. The big "if's" are the extent to which shorter cars replace bigger cars and the economics of changing over assembly plants.

A major objective of body engineers is to produce thinner doors. The major obstacle is the growing complexity of door mechanisms. Use of curved glass in doors (except by Chrysler Imperial) has not caught on.

Most cars today continue to use a stamped steel instrument panel. The instrument cluster may be a die casting or molded plastic. Instrument panel glare presents a difficult problem. A scratch or a mark brightens the surface, which then reflects light. It is much harder to make a surface permanently dull than it is to make it bright, according to body engineers working on this problem.

With respect to grilles the competitive struggle between stamped or extruded aluminum and zinc die castings goes on. The final decision depends on the design of the grille and the total cost of tooling plus unit production cost. Tooling cost must always be included in deciding which way to go, say the production engineers.

The following list of outside trim materials used in the 1962 Chrysler gives an indication of current industry materials specifications.

Bezels	Zinc die casting
Bumpers	Cr-plated steel
Door handles	Zinc die casting
Grille	Stamped and expanded mesh anodized Al
Moldings	Mostly stainless steel
Hub Caps	Stainless steel
Wheel covers	Stainless steel

Use of plated plain carbon steel for exterior trim has practically disappeared. Most steel trim today is chrome-type stainless with an extra flash of chromium. Use of aluminum trim is increasing. Aluminum reduces the electrolytic corrosion problem.

Plastic clips are being used on several assembly lines to attach body trim. Plastic fasteners fill up the body holes and avoid damage to paint during assembly operations.

Car designers recognize that glass is about the most costly — and the heaviest — material used in an automobile. Glass areas are being reduced in size. A great deal of work is going on, aimed at improving the structural properties of glass. Successful use of glass structurally depends on two things: ability to improve the physical properties of glass (tempered glass, for example), so that thinner sections may be used, and improvement of glass mountings so that glass serves more effectively as a structural member. Much progress has been made toward the first objective; thus far, the second objective seems to be more elusive.

Substantial progress is being made on adhesives for attaching short pieces of body molding. Long sections of molding still present a problem. Exposure to very high or very low temperatures or repair in the service shop is not a problem. Use of adhesives is still in an early state of development; extensive automotive use to attach body molding may be five years away.

Aircraft experience with adhesives is not directly applicable to automotive problems. These specifications must be met: very fast drying is necessary; it is difficult always to provide a perfectly clean metal surface as the car comes down an assembly line; and adhesives must be developed that resist contamination by body polish, oil, and other foreign materials.

A study of body dimension trends is essential to any discussion of automobile body engineering. Charts from recent SAE papers[2,3] show that from 1950 to 1959 the overall length index rose from 205 to 219. The index stabilized in 1960 and declined in 1961. Wheelbase trend roughly parallels the overall length trend. The gain in overall width was less than 5 in. during this 10-year period.

Meanwhile, shoulder room was increasing at about the same rate as overall length. Legroom held relatively steady until 1956, when legroom in the front seat increased while legroom in the rear seat actually dipped noticeably for several years, but has recently been increasing.

During the same period, glass area has increased steadily, as has the average size of the luggage compartment.

During the same decade the weight (pound) index increased from about 3800 to a peak of 4300 in 1959. The average has dropped back to less than 3900 lb in 1961 as a result of the influx of smaller cars.

A number of the 1962 cars have achieved some minor gains in providing more legroom in the rear seat as a result of design changes. Several car producers have made gains in legroom in the front seat by reducing the size of the transmission and moving the engine forward in the frame.

Body corrosion is probably getting as much attention today from body engineers as any single problem. There are good reasons for this: body corrosion

[2] "Dimensional Analysis of Vehicles — Why, How, What," by J. Nagy and A. Seligson. SAE Paper No. 325B (1961).

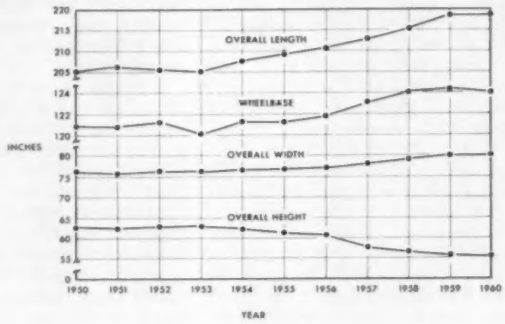
[3] "Role of Weight Analysis in Vehicle Evaluation," by R. W. Brown and A. Seligson. SAE Paper No. 325A (1961).

is indeed serious where a structural member is involved, and a rusted-out rocker panel is a poor advertisement for any car.

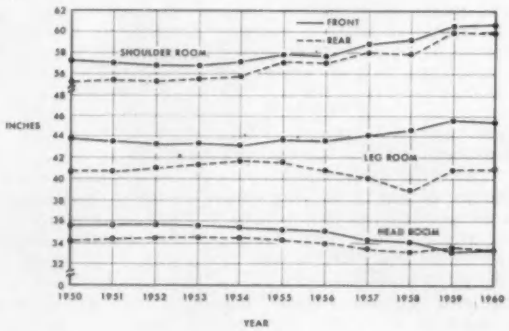
Use of zinc-coated steel is growing rapidly. Metal gage has been boosted at critical areas. There are welding problems—but these are mostly annoying problems rather than unsurmountable problems.

Dipping may not be the final answer. In certain areas — box members, for example — dipping may fail to cover the inside surfaces. Or the protection may wash off during drying. The two most vulnerable areas are probably the rocker panel and the rear, lower front fender area just ahead of the rocker panel. Use of zinc-rich primer helps, but it's also expensive. The corrosion protection problem is made more difficult by the use of large amounts of salt or steel mill slag to clear icy streets. Here are some specific steps to combat corrosion that are being taken by automobile manufacturers:

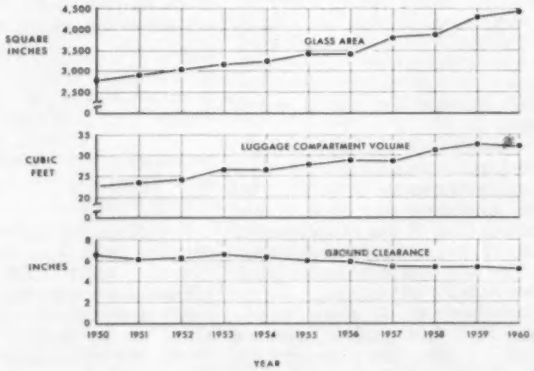
Special attention is being given on the Buick Special to all cross bars (galvanized) and to forward sections of the galvanized steel motor rails.



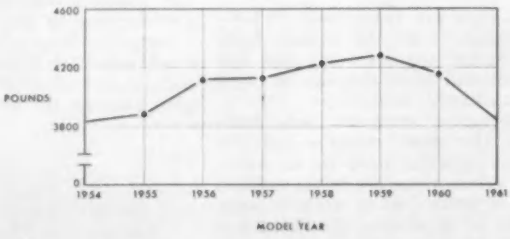
TREND OF EXTERIOR DIMENSIONS from 1950 to 1960 (from Nagy and Seligson[2]).



TREND OF INTERIOR DIMENSIONS from 1950 to 1960 (from Nagy and Seligson[2]).



TREND OF MISCELLANEOUS EXTERIOR DIMENSIONS from 1950 to 1960 (from Nagy and Seligson[2]).



TREND OF CURB WEIGHT from 1954 to 1961 (from Brown and Seligson[3]).

Saturated zinc primer is used in addition to regular paint protection. According to many engineers, tests show this type of protection is superior to dipping. This method, it is argued, gives "controlled protection" in critical areas such as the rocker panel. The primer is air dried rather than oven dried.

Buick started its present methods of construction in 1958 and 1959. Areas behind the outer panel are now sealed. Using both new construction and new primers, corrosion resistance is said to be much improved.

Other areas where gains are being made by Buick and others is in protecting against dust. On doors, for instance, new door seals are used effectively to keep out dust which might otherwise collect inside the door. When dust becomes wet, it acts very effectively in sustaining and spreading corrosion from the inside. In addition to zinc-rich primer and galvanized steel, improved methods of ventilation have helped Buick to arrest corrosion.

Rocker panels and underbody superstructures of the new Ford Fairlane are galvanized. Besides galvanizing, zinc-rich primer, bonderizing, and epoxy primer are used. Zinc coating serves as a barrier; this also adds protection through sacrificial "galvanic action." All principal underbody structual components of the Fairlane are galvanized. Where galvanizing is impractical, zinc-rich primer is used. Zincilate is applied to the Fairlane on the inside of large panels, inner rocker panel, quarter panel joints, and welds. After bonderizing, the Fairlane receives epoxy primer.

Body dipping is not used by several large producers. Zinc-rich primer is used extensively by Fisher Body Division on rocker panels and other critical areas; no steel galvanized on both sides is used. Forming galvanized steel is not a serious problem, it is indicated, but getting a good paint finish afterwards on the ungalvanized, steel surface is a problem, it is agreed. Stop-off is used to prevent galvanizing on one side of the sheet and failure to clean this surface before paint is applied creates the problem.

Zinc-rich primers, loaded with free zinc, are used extensively on Fisher bodies. Fisher Body Division applies the zinc-rich primer in the press shop, then assembles the section. A prime spray is applied afterwards to cover any areas where protection may be burned off during welding.

On Mercury Monterey, zinc phosphate rust inhibitor and epoxy primer paint are sprayed over the entire body, inside and outside, this year. Extra protection is given to all lower body areas. Asphalt-base mastic is sprayed along the fender, wheel wells, and areas that receive wheel splash. Rocker panels are galvanized steel. Extensive used is made of sound-deadening material.

More than 250 lb of galvanized steel is used in critical areas in the Lincoln Continental. Rocker panels and all underbody main members are galvanized.

More efficient design of many new body and chassis components has reduced noise on the new Plymouth. Engine mountings are new. The steering column is more rigid and better sealed. Heater system noise levels are reduced. Body mechanisms are smoother and quieter operating. Engines and starters are quieter. Throttle linkage is freer from vibration. The sound problem is more difficult with unitized construction.

Fisher Body Division will use 26 different types of sound-deadening material on its new models.

Asphalt mastic adhesive sound deadener is sprayed over the entire Ford Fairlane underbody and inner body compartment areas. All wheel housings are sprayed with sound deadener. The cowl top and sides are insulated by a ½-in. blanket of fiberglass or amberlite. All reinforcement ribs are filled with asphalt deadener.

Areas where additional insulation and sound deadening materials have been added to the Ford Thunderbird include hood, wheelhouse, dash, instrument panel, passenger and luggage compartment floors, roof panel and rails, package tray and quarter panels.

Sound deadener for the Lincoln Continental floor pan is 33% heavier this year. Felt sound barrier for front body cowl is 33% heavier. A 16-in. wide strip of undercoating is applied to the outboard areas of the underbody. Cables and hoses are routed through grommets and sealed in the dash panel. All body access holes are sealed.

Dash panel on the Continental is insulated with extra-heavy faceboard-type sound deadener and 1-in. fiberglass. Another blanket of fiberglass, 2 in. thick, covers the area beneath the instrument panel.

The entire area of each outside quarter panel is sprayed with sound deadener. Pockets and hollow areas such as those between the rear wheelhouse and the quarter panel are filled with sound-absorbing cellulose wadding. Entire floor pan areas and the area behind the rear seat is blanketed with aluminum foil-faced fiberglass on air conditioned vehicles.

On the Mercury Monterey, wires passing through the cowl are installed in tight-fitting multiple connectors. The car has 90 sq ft of sound deadener and 170 sq ft of blanket insulation, which are sprayed on. Steel-and-rubber insulation isolates the steering column. An abrasion-resisting undercoating is sprayed under the front fenders.

Steady progress is being made in safety engineering. Providing more safety for the motorist, as a result of improved body design, better brakes, improved lighting and other safety features goes on steadily. The problem is to provide more safety within the price range the customer is willing to pay.

Installation of safety belt anchors for the front seat is probably the most important addition on the 1962 cars.

There have also been significant improvements in door locks. Door locks for the Ford Fairlane are a new self-centering design. The doors close very easily. The new lock striker is a solid pin with a flanged cap, attached to the door pillar. The pin has a rubber shock bushing surrounding it. An external metal sleeve protects the rubber bushing. Door lock assembly is of the clamp or yoke type, with dual grip arms. When the door closes, the yoke centers over the striker pin and locks securely in position.

The new door latching and locking system for Chrysler Corp. cars is simpler in design and easier to service and adjust. The latch mechanism permits overtravel on the inside remote door handle, eliminating the need for adjustment. Outside door handles are of the push-button type. New door hinges have a torsion bar check mechanism.

Average height of the Buick front tunnel has been reduced about 2 in. The rear tunnel is relatively unchanged but the center of the rear seat cushion is much improved, having now approximately a 6-in. cushion depth.

Reduction in Buick tunnel height and width was accomplished by moving the engine and transmission forward 4 in. The rear seat heater duct has been eliminated from the top of the tunnel area and replaced by two smaller ducts formed into the floor panel, one at each side of the tunnel.

The new instrument cluster has a swing-needle-type speedometer. Trip odometer, safety buzzer, and brake warning light are available at extra cost. Full-size models have a smaller (16 in.) steering wheel.

A total of five bodies (4-door and 2-door coupes) have been added to the Cadillac line. Overall length is 222 in. on eight models. The will be two 215 in. sedan models. On an average, length is decreased 3 in.

Chevrolet has a new anodized Al grille.

There is an important change in the method of measuring body dimensions. Most important new procedure is a change in the basis of reference. A new dummy is used. Using the new "Oscar" as a reference, dimensions and angular measurements portray more realistically the passenger's seated attitude and relative comfort. Dimensions most affected by the new procedure are headroom, entrance room, and vertical and horizontal steering wheel clearances.

A new front fender skirt covers the front wheel and protects the fender inner surface from corrosive elements. Bolted to the fender with seven bolts, the new skirt effectively exposes the entire inner surface to the drying action of the engine heat. Now enclosed,

the fender is no longer vulnerable to roadsplash, mud, and stones.

Front seat dimension of the new Chevy II compares favorably with the 1957 Chevrolet. Luggage space more than doubles Corvair capacity. From the dash panel rearward, body and frame are integrated with structural framing members, welded to the underbody. Forward of the dash panel, the front end is unitized to form a box structure that is welded to the body at four reinforced areas. The Chevy II body features weight reduction, greater torsional rigidity, compact exterior dimensions, with surprising interior roominess. The unitized front end has bolted-on fenders.

Chrysler Corp. bodies make greater use of welding. Improved weather sealing provides more effective sealing of doors and makes door opening and closing easier. The powerplant is located forward and downward in the car. A lower transmission tunnel permits deeper springs in the center of the front seat. New torsion bar check mechanisms are used on door hinges.

Ford Fairlane will have bolt-on front fenders. Doors close with a minimum of effort, made possible by the new lock design. Rocker panels and underbody structural members are galvanized. Heavy gage galvanized steel is used for box section body sills, extending from cowl to the rear wheel house. Box-section cross-members are welded to the floor.

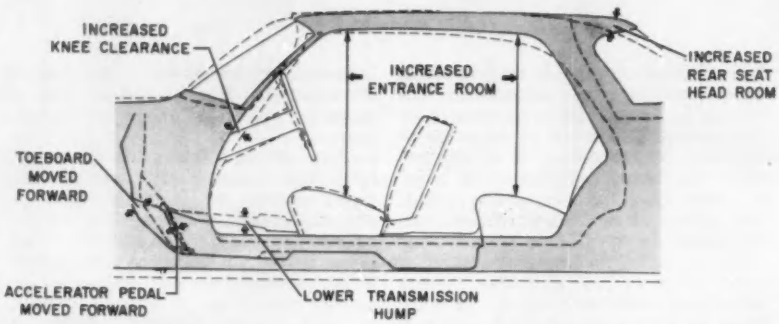
Four steel torque bosses are used with the Fairlane unitized body. These are structural members designed to absorb force, vibration, and torsion or twisting action. This is the first U. S. use on a unitized body. The front rails are tied to their torque boxes, permitting the box to twist or rotate rather than transmit force to the vehicle. Front torque boxes are *not* connected to the floor pan, minimizing movement or vibration felt in the passenger compartment. Rear torque boxes *are* connected to the floor pan for structural design reasons.

Most Ford Galaxie body stampings are new. New seals and weather strip eliminate wind noise. Weld-in door frames are reported to improve rigidity.

New rear body sheetmetal is used for Comet sedans.

Front fenders of the Comet are bolted to the front aprons, radiator support, front splash shield, and body cowl. Underbody framing members are twice as heavy as conventional body steel. A box girder front end framing provides solid mounting for front suspension and engine. Five full cross-members are welded to the floor. Stamped in rib-stiffeners add rigidity. Thin windshield posts and body side pillars are built-up box sections.

Mercury Monterey Custom is a new series. Wheelbase remains at 120 in. but new cars are 1 in. longer overall than the 1961 Monterey. The roof is extended 4 in. on the 1962 models.



PASSENGER-CAR ROOMINESS has been improved on Dodge Dart. Similar benefits are found on many of the other 1962 cars.

This provides more front seat headroom and additional eye shade. Door panels are trimmed with a combination brushed metallic vinyl, used for the first time. Double front body mounts are located to tune out road vibrations. Rib stiffeners and welded-in steel gussets add durability and strength. Door frames are reinforced. Hood and rear deck are double-paneled.

Structure of the rocker panels and rails is much heavier gage in the Lincoln Continental convertible. Side sills or rails on standard models are double-box members. Front torque boxes are located under the dash and the toe pan between the side sill and front suspension assembly.

Although Oldsmobile standard models appear to be much longer, they are actually less than 2 in. longer than the 1961 Olds. Most of the increase in length is accounted for by a change in rear quarter panels, rear deck and bumper design. New steel roof designs, with a "convertible" top appearance, will be the outstanding change. There are extensive sheetmetal changes in standard cars, including new grilles, front fenders, and rear end styling. Rear vision overhang has been eliminated. New, larger body mounts are used this year.

Thin Plymouth doors permit full use of the car's width. High roof rails and straight A pillars permit easier entry and exit. The flush instrument panel gives maximum knee room. The Plymouth powerplant is located further forward and downward in the car. Smaller chassis components permit a reduction in tunnel dimensions. By moving the toeboard forward 1 in., the passenger compartment has been enlarged. Accelerator pedal leg room has been increased about an inch. The lower transmission hump provides more legroom for the passenger in the center of the seat.

Compared with 1961 models, Plymouth for 1962 has 4 in. more rear seat legroom. Horizontal room in the rear compartment is increased 2.2 in.

Seats for many of the new cars are more comfortable. Rear seats for Plymouth, for example, feature a more natural sitting posture; improved support is provided. Plymouth seats have improved springs, and they have better deflection characteristics. Fury models have foam front seat cushions that are 2¼ in. thick (an inch more than last year).

Ambassador V-8 will be built on 108 in. wheelbase (was 117 in.) with 250–270 hp engine.

A concealed center pillar gives the appearance of a hardtop. Glass area is increased this year. The windshield is 2-in. higher. Deluxe models have no side moldings. American is unchanged except the grille.

Overall length and height are increased slightly, but the width is unchanged. There is an increase in rear seat legroom.

Seats have deeper coil springs. Front seat cushions are softer, adding to effective headroom. An 18-in. wide cushion gives improved leg support. Front and rear seat springs are treated with Acoustacoil rubber coating for soundproofing and stabilizing.

New Lounge-Tile seat option has a handle, located on the right side of the passenger seat. This actuates a hydraulic cylinder, which raises the front cushion to any desired degree.

Safety padded instrument panels and padded sun visors will be standard on all 400 models and optional on others. Seat belts are a factory-installed option. Inside rear view mirror of the Rambler has a double ball joint arm.

Surfaces of Rambler underbody side sills (rocker panels) are galvanized. Steel galvanized on both sides is specified. Special manufacturing techniques have been developed to provide a good finish over galvanized steel.

Most exterior trim will be attached with nylon clips to minimize corrosion, replacing wire clips.

Overall body lengths have been increased on the Studebaker Lark model. The new 4-door Lark sedan is 13 in. longer and the Lark Cruiser is 9 in. longer. The 2-door Lark sedan, hardtop and convertible have been lengthened 9 in. The 4-door model wheelbase has been extended 4½ in. The frame of all Lark models except the station wagon has been lengthened.

Seat belt anchors will be installed in *both* front and rear of all the 1962 Studebaker-Packard cars.

The Hawk has been changed from a coupe to a sports-type hardtop with a new body. All S-P cushions have coil springs. Cushions, front and rear, are 1 in. wider.

Oil additives can aid equipment designer

Potentialities should be recognized in early stages of equipment planning and development

Based on paper by

L. W. Manley and N. V. Messina

Socony Mobil Oil Co., Inc.

ADDITIVES properly incorporated in mineral oils allow the equipment designer to do things that otherwise would be impossible. Additives alter the performance properties of oils much as alloys vary the properties of metals. They make it possible to go to higher temperatures, higher output, and lower cost design.

Viscosity index improvers

For equipment exposed to low ambient and high operating temperatures it is desirable to have a lubricant or hydraulic fluid varying as little as possible in viscosity over a wide temperature range. Additives known as viscosity index or V.I. improvers impart this desirable property and they are used principally in cross-graded engine oils and in automatic transmission fluid.

Under shearing conditions the V.I. improved oil will lose some viscosity due to breakdown of the polymeric additive. Hence, the designer must recognize that viscosity will change with use. He should also be aware that V.I. improved oils exhibit non-Newtonian flow behavior, that it, vary in viscosity with the rate of shear.

This phenomenon is shown in Fig. 1, the data being obtained in a high shear rotational viscometer. As the shear rate is increased above a certain point, the viscosity of the V.I. improved oil decreases. As the shear rate is decreased, the viscosity increases, following the same curve back to the starting point. The base oil at the bottom of the chart is Newtonian and does not vary with rate of shear. So the change is due to the added improver. This variation with shear can be important in the design of hydraulic controls and other precision mechanisms.

Detergent-dispersant additives

Detergent-dispersant type additives keep engines and equipment clean by holding sludge and deposits

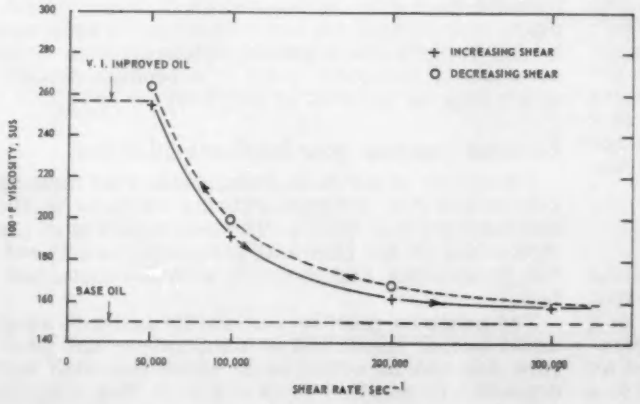


Fig. 1 — Effect of shear rate on V.I. improved oil at 100 F.

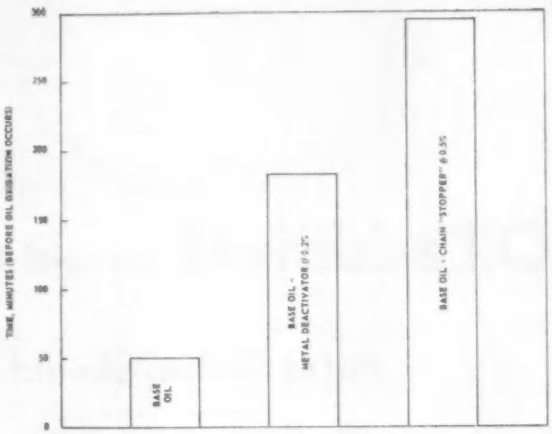


Fig. 2 — Oxidation inhibition using oxygen absorption test at 150 C shows benefit of using a sulfur-phosphorus and a phenolic-type additive.

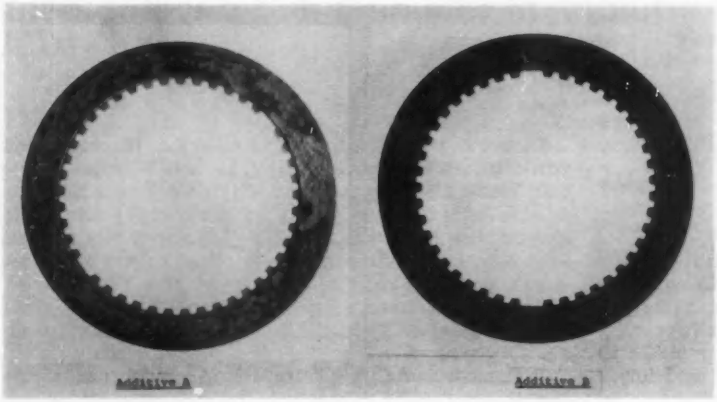


Fig. 3 — Effect of extreme pressure agents on transmission clutch plates. Friction material was almost entirely destroyed by additive A, while additive B showed no ill effects.

Oil additives can aid equipment designer

. . . continued

in suspension. Most of them are alkaline barium and calcium compounds, but non-metallic or ashless types are available. The non-metallic are regarded as good dispersants for sludge and deposits formed under low engine operating temperature conditions, but relatively poor in high temperature detergency properties as compared with the metallic types.

These additives may have an adverse affect on the critical properties desired in a specific application. In hypoid gear lubrication, for example, metallic detergents depreciate the effectiveness of load-carrying and friction reducing agents. In passenger car tests, addition of a barium or calcium detergent to an e-p additive-containing oil depreciated gear scoring protection, and this same phenomenon has been noted in other applications where friction and wear properties are altered by a detergent.

Metal deactivators and oxidation inhibitors

Generally speaking, the most severe condition imposed on a lubricant or hydraulic fluid is exposure to high temperature oxidizing conditions. As a general rule, for every 18 deg increase in temperature, the rate of oxidation is doubled. Thus, at an operating temperature of 300 F the life of an oil to a given acid and deposit level is only about one-thirty-second as long as at a temperature of 200 F.

Fig. 2 illustrates the beneficial effect of using a sulfur-phosphorus and a phenolic type additive for inhibiting oxidation in a laboratory test.

Oxidation-inhibited oils are helpful to designs for high operating temperatures, but the temperatures must be kept within limits which will not exceed the thermal breakdown threshold of the additives used. The additives tend to break down thermally (not oxidize) at lower temperatures than the base hydrocarbon oil. Thus, while inhibiting oxidation of the bulk oil, the additive itself may decompose to form harmful products. Some zinc dialkyl dithiophosphate-type compounds are very effective oxidation inhibitors, yet thermal decomposition occurs at temperatures in the order of 275 F to produce deposits which may be harmful or corrosive.

Extreme pressure gear lubricant additives

Prevention of metal to metal contact by forming a chemical film between rubbing surfaces is the function of e-p additives. The film results from the interaction of the chemical groupings, usually sulfur, phosphorus, and chlorine, with the metal surface.

The additives must be sufficiently active to react under proper conditions of temperature and pressure, but not so active as to cause corrosion and deposits. In addition to having good load carrying

and antiscoring properties both under conditions of heavy duty low speed, high torque and passenger car high speed, shock loading, a gear lubricant must meet other requirements. These are:

- Good thermal and oxidation stability.
- Rust prevention.
- Antifoam performance.
- Non-corrosivity toward non-ferrous metals.
- Proper physical characteristics for all-weather operation.
- For vehicles with slip-limited differentials — proper frictional properties to prevent chatter of engaging clutch devices.

Within any class of gear lubricant additive there will be considerable variation in performance depending on the particular material tested, however, a reasonable comparison of representative members of each class shows oils having the highest antiscore factors to be generally poorer with respect to high temperature stability or non-ferrous metal corrosion properties.

To have a lubricant with good high temperature stability, it is usually necessary to relax somewhat on load-carrying and antiscoring ability. At times this can be compensated for by larger or more rugged design, or by surface treating of the gears. Phosphate treating of gears, for example, greatly reduces e-p requirements to permit use of a more thermally stable gear lubricant.

Friction modifying or "lubricity" additives

Friction modifying properties of lubricants have become extremely important with the increasing use of hydraulically-actuated clutch plates in both passenger car and heavy-duty equipment power transmission systems. If the clutch engagement time in an automatic transmission is too short, the shift is jerky and rough and may produce an audible squawk; if the time is too long, the plates slip excessively resulting in clutch plate burning and engine over-speeding.

The time of engagement can be controlled by the frictional properties of the fluid. In an automatic transmission test, performance was jerky with 1.6% friction modifier in the fluid. With 2.1% friction modifier the performance was satisfactory, but clutch plate slippage and engine over-speeding resulted when the modifier was raised to 3.2%.

Additives for transaxles

For a single fluid to meet the requirements of a transaxle it must have the performance characteristics of an automatic transmission fluid and a hypoid gear lubricant. However, in general the e-p agents for hypoid gear oils are much too unstable to meet the requirements of an automatic transmission, so the problem was to develop non-corrosive e-p agents of much higher thermal and oxidative stability.

E-p agents with stability and good antiscore protection were developed, but it was found that some were incompatible with transmission clutch materials. Contrasting examples are shown in Fig. 3. Some were also incompatible with the nylon governor gear used in a particular design of transmission, as shown in Fig. 4.

The friction properties of fluids were also affected by e-p additives. The lowered coefficient of friction can cause failure of clutch plate friction elements because of excessive slippage. Moreover, additive systems producing too low a coefficient of friction can adversely affect the static breakaway coefficient of the fluid, thus causing low band slip or preventing plates from remaining locked. The lowering of the static coefficient of friction through e-p additives is shown in Fig. 5.

However, by proper formulation of various additives, performance approaching transaxle requirements can be achieved and a completely satisfactory solution to the transaxle problem seems assured.

To Order Paper No. 397A . . .
from which material for this article was drawn, see p. 6.

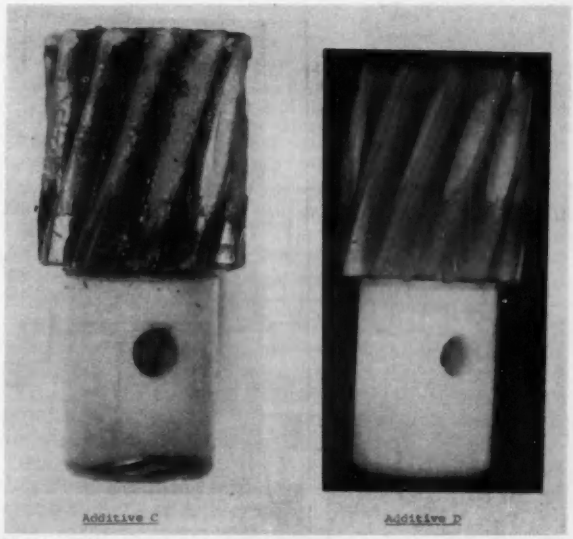


Fig. 4 — Effect of extreme pressure agent on nylon governor gear. Additive C proved incompatible, while additive D left gear in good condition.

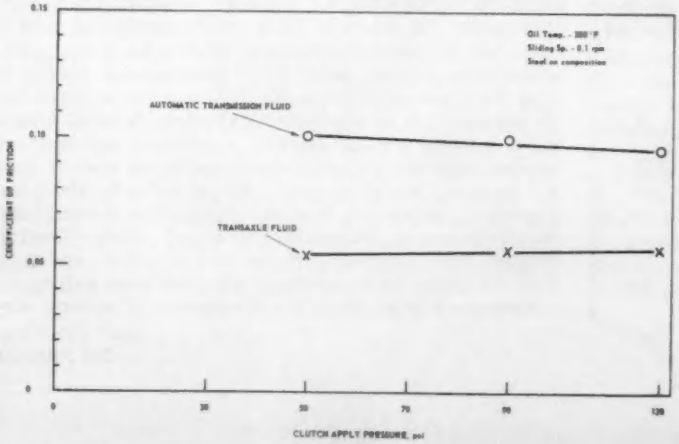


Fig. 5 — Lowering of static coefficient of friction by addition of e-p agent. This transaxle fluid, with a consistently lower static coefficient than an automatic transmission fluid, resulted in low band slip in actual road test.

Europe's Small Aircooled Engines TODAY

- Gasoline engines feature refinements.
- Diesel advances pushing gasoline engines to low-power, light-duty applications.

Based on paper by **W. E. Meyer**
The Pennsylvania State University

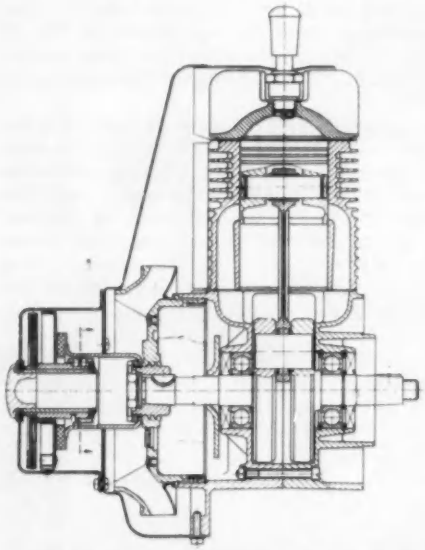


Fig. 1 — Hirth Type 8 Engine has 15.2 cu in. displacement and is rated 8 hp at 4200 rpm. 12.2 cu in. sister engine weight was reduced 10% to under 10 lb per hp at 3000 rpm by refinements.

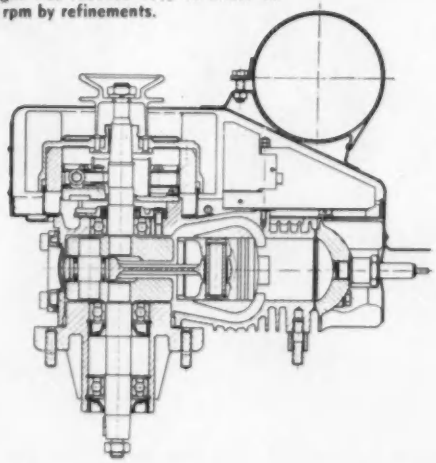


Fig. 2 — Hirth 71W1 Engine has 5.2 cu in. displacement and is rated 2.5 hp at 3600 rpm. Cylinder and crankcase are single casting.

SMALL, AIRCOOLED GASOLINE AND DIESEL ENGINE DEVELOPMENTS in Western Europe since 1957 are covered in this article. Professor Meyer thus brings up to date his report European Solutions of the Design of Small Aircooled Engines (SAE Journal, Sept. 1957) in which he discussed the state-of-the-art prior to 1957.

SMALL GASOLINE ENGINE development in Western Europe since 1957 takes the form of refinements to meet changing market conditions. Diesel advances, however, are tending to relegate gasoline engines to lower-power, light-duty applications — with the heavy-duty field (4–5 hp and up) tending to become the domain of the diesel.

Gasoline Engines

Europe's small gasoline industrial engines remain two-cycle units. Some have undergone modernization, but the steps taken have been refinements rather than innovations. Most frequently types and models have been realigned and production simplified . . . and some weight savings effected thereby. Two new Hirth engines, for example, replace older ones of the same displacement (12.2 and 15.3 cu in.). The 3000 rpm ratings have remained the same: 5 and 6.5 hp, but the permissible maximum speed under full load has been increased to 4000 rpm.

The general design of these two engines (Fig. 1) is typical of most European two-cycle engines: built-up crankshaft, rolling contact bearings througout, three-port loop scavenging, cast-iron cylinder, detachable pressure cast light-alloy head, aluminum piston, and 25/1 gasoline-oil mixture. New features include a slightly increased bore-to-stroke ratio, a little longer cylinder, heavier bearings, heavier crank cheeks, increased number of cooling ribs on cylinder, sheet metal instead of cast air shroud, recoil starter now standard, air vane governor, improved flywheel magneto or combined magneto — a-c generator flywheel unit. Engine weight was reduced 10% on the smaller model to slightly under 10 lb per hp at the 3000 rpm rating.

New are the vertical shaft versions of several en-

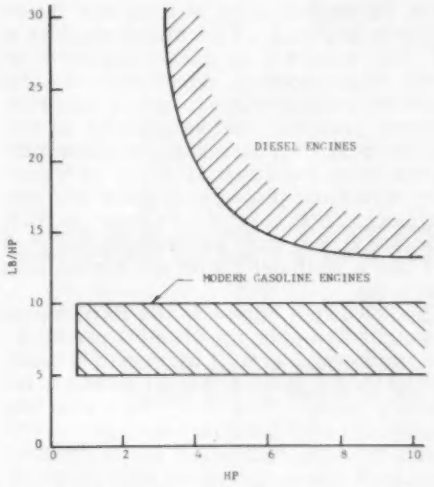


Fig. 3 — Specific weight of even the lightest diesels runs higher than the new gasoline engines.

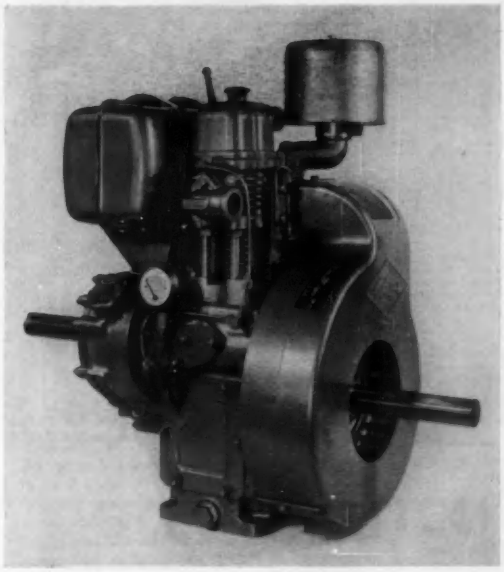


Fig. 5 — Petter PC 1 Diesel Engine has 21.2 cu in. displacement and is rated 5 hp at 3000 rpm. Engine is open chamber type with nearly hemispherical depression in piston. Shrouded intake valve induces air swirl. Engine features flywheel fan.

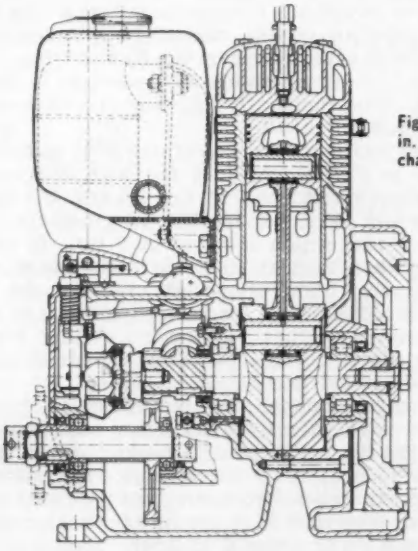


Fig. 4 — Sendling DL 107 Diesel Engine has 19.2 cu in. displacement and is rated 4 hp at 3000 rpm. Open chamber is unusual for small loop-scavenged engine.

gines, but most differ little from standard models. Fig. 2 shows the 2.5 hp (at 3600 rpm) Hirth engine which features cylinder and crankcase as a single casting.

Diesel Engines

Among diesels there is somewhat more that's new. There are a number of new low horsepower engines that attain their rated output at 3000 rpm. (The 3000 rpm is somewhat of a target speed in Europe because of the 50 cps frequency that is standard for a-c.) With this speed the diesels move into direct competition with the larger small gasoline engines.

Fig. 3 shows that even the lightest diesels are much heavier than the newer gasoline engines. Thus the gasoline engine will probably remain dominant wherever low weight is a must.

Since it is the time available rather than the rotational speed of the crankshaft that limits the successful handling of combustion, it is not suprising that only one two-cycle diesel is offered with a 3000 rpm rating. This is the smallest diesel engine available. It is rated 4 hp. Any larger two-cycle is rated at 2500 rpm or below. The specific weight (lb per hp) of these engines varies over the same range as that of competitive four-cycle engines.

Fig. 4 shows the 4 hp Sendling engine. In all major features, designs are quite similar to those of gasoline two-cycle engines. Its displacement is 15.2 cu in. and its maximum bmep 34 psi. It weighs 21 lb per hp. It has an open chamber which is unusual for a small loop-scavenged engine.

Starting such an engine can be a problem and therefore Sendling provides an auxiliary shaft to which the crank is connected. Since there is a 3/1 gear ratio between the auxiliary and the engine shaft, fairly good cranking speeds can be developed even with hand cranking. The large gear on the auxiliary shaft dips into an oil sump and the splash oil is conveyed by a small bore into the crankcase where a slinger feeds it to the hollow of the crankpin. In this way and through the hollow rod the needle bearings in both connecting rod ends are lubricated. Cylinder lubrication is entirely dependent on incidental splash.

The flywheel also serves as cooling air blower. This is the only two-cycle diesel so equipped. All others have separate blowers. However none has a scavenging pump or blower. All depend on crankcase scavenging.

The four-cycle diesels begin at 5 hp. A single

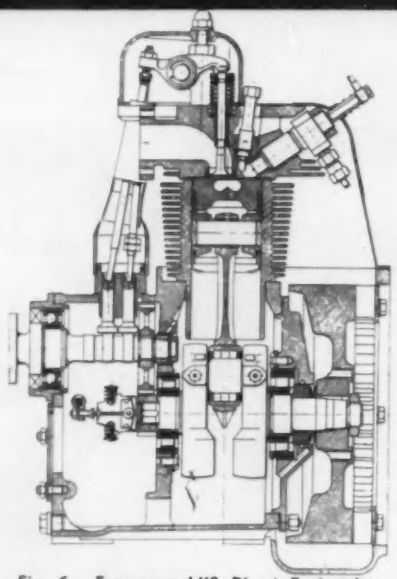


Fig. 6 — Farrymann LKS Diesel Engine has 16.8 cu in. displacement and is rated 5 hp at 3000 rpm. Engine has open chamber and piston with toroidal depression. Camshaft lies in the same vertical plane as the crankshaft and is designed so that it can serve as half-speed power takeoff.

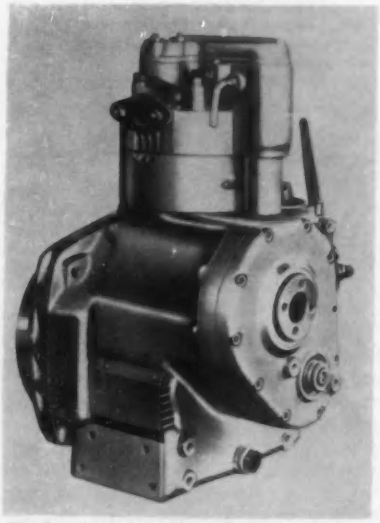


Fig. 7 — Hatz E 75 Diesel Engine has 21.5 cu in. displacement and is rated 6 hp at 3000 rpm. Engine weighs only 16.5 lb per hp. Engine features turbulence chamber. Cooling air enters at head, flows down vertical ribs of the cylinder, and is discharged to atmosphere by flywheel fan. Camshaft can serve as power takeoff.

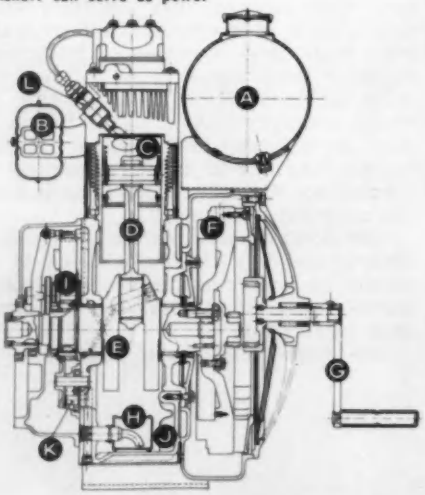


Fig. 8 — Bernard W31 Diesel Engine has 31.2 cu in. displacement and is rated 9 hp at 3000 rpm. Engine has open chamber with ellipsoid piston cavity and pintle nozzle. Light alloys are used for head and crankcase.

cylinder Petter PC engine rated at 5 hp per cyl at 3000 rpm is shown in Fig. 5. This model employs a flywheel fan. The engine is an open chamber type with a nearly hemispherical depression in the piston, and shrouded intake valve to induce air swirl. Its design follows practices well established in the automotive diesel field. For instance, the aluminum alloy piston has three compression rings of which the top one is chromium plated and there are two oil control rings. This is a heavy-duty engine. Cast-iron construction is used throughout, so that its specific weight is 48 lb per hp for the continuous duty rating of 5 hp.

Another 5 hp, 3000 rpm engine is the Farrymann (Fig. 6). It weighs 22 lb per hp which is considerably less than the Perkins even if allowance is made for the fact that the Farrymann 5 hp represents an intermittent-duty rating. The Farrymann also has an open chamber, but with toroidal depression in the piston. It has a built-up crankshaft and a flywheel fan. The camshaft lies in the same vertical plane as the crankshaft and is so designed that it can serve as a half-speed power takeoff.

Hatz has a new small 3000 rpm engine (Fig. 7). It is rated at 6 hp and weighs only 16.5 lb per hp. It has a turbulence chamber. Its main distinguishing feature is that the cooling air enters at the head, flows down along vertical ribs of the cylinder, and is discharged to atmosphere by the flywheel fan. This is claimed to permit substantial savings in weight and bulk. The camshaft can, as in the Farrymann, serve as power takeoff.

Bernard has an entire line of new 3000 rpm diesels available in single, two, and four cylinder models. The smallest series has 6 hp per cyl and the largest 11 hp per cyl. Fig. 8 shows the intermediate single cylinder model which is rated at 9 hp. It has an open chamber with an ellipsoid piston cavity and pintle nozzle. Light alloys are used for the head and the crankcase and for various subsidiary parts. The Bernard engines employ no rolling contact bearings except for the camshaft which is located to the side of the crankshaft.

There is no evidence that East Europe's developments of small diesel engines are comparable to those of the West. The East's most advanced engine is probably the 31 cu in. Slavia from Czechoslovakia. It is a prechamber two-cycle that is rated 6.5 at 2200 rpm. It weighs 35 lb per hp and has an aluminum cylinder with pressed-in liner. The light-alloy head has a cast-in steel reinforcing plate. In other respects it resembles the engines described here.

We will probably see further reductions in weight, but price will remain the main handicap of the diesel. The average diesel horsepower still costs about twice as much as a gasoline horsepower. Weight is not critical in many applications, but price always is. Much of the blame for the diesel's high price is placed on the accessories.

To Order Paper No. 394A . . .
from which material for this article was drawn, see p. 6.

Geared torque converters give better performance

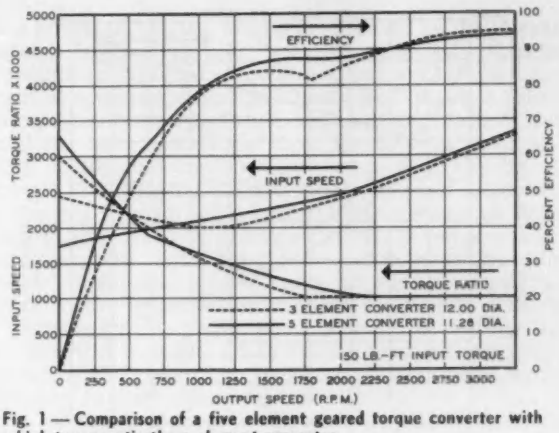

EFFICIENCY
INPUT SPEED
TORQUE RATIO
3 ELEMENT CONVERTER 12.00 DIA.
5 ELEMENT CONVERTER 11.28 DIA.
150 LB.-FT INPUT TORQUE
TORQUE RATIO X 1000
INPUT SPEED
PERCENT EFFICIENCY
OUTPUT SPEED (R.P.M.)
0 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
0 10 20 30 40 50 60 70 80 90 100

Fig. 1 — Comparison of a five element geared torque converter with a high torque ratio three element converter.

They offer light throttle starts and good efficiency . . . without shifting.

Based on paper by

F. H. Walker

Buick Motor Division, GMC

BROAD ratio coverage and high efficiency, not possible in a pure hydrodynamic torque converter, can be attained by incorporating mechanical gear trains with the converter. With such a system the smooth torque characteristics of the pure hydraulic converter can be retained.

A five-element two-turbine geared converter is compared to a high torque ratio three element converter in Fig. 1. The torque ratios at stall are about equal but the efficiency of the geared converter rises more rapidly and peaks at a higher value than the three element converter. The geared converter also has a rising input speed with increasing output speed while, at the lower speed ratios, the three element converter has a falling input speed characteristic with rising output speed. This falling speed characteristic gives an unusual feeling in an accelerating automobile . . . as though the engine were stalling or being excessively loaded. As a result, three element torque converters used in domestic transmissions have ratios of 2.7 or less. The majority have stall ratios between 2.2 and 2.1. This requires that the three element converter be combined in the transmission with a shifting gear set, resulting in either a two or three speed transmission.

The main objective of the multiturbine converter is to provide a transmission requiring no shifts in a normal acceleration from stop. Fig. 2 shows the characteristics of a two speed transmission having a three element converter and a five element geared converter.

The geared converter

A cut-away drawing of a four element geared converter is shown in Fig. 3, and the schematic representation of the arrangement is shown in Fig. 4. The first turbine is mechanically connected to the ring gear of the planetary set. The planet carrier acts as the output member, and the sun gear as reaction. The first turbine torque, therefore, is multiplied by the planetary gear ratio r to the output shaft.

The second turbine is directly connected to the output shaft, so that the total output torque of the converter at all speed ratios is represented by the equation:

$$T = r \cdot T_{T1} + T_{T2}$$

The oil in the converter travels outward through the impeller into the first turbine, inward through the second turbine and back to the impeller. At stall, the oil leaving the impeller has a high tangential velocity component and enters the stationary first turbine as a revolving hollow cylindrical extrusion of oil. A high mechanical torque is imparted to the first stationary turbine since the rotating component of the velocity changes direction as it passes through.

The oil enters the second turbine as it left the first turbine, with its rotational component opposite in direction to that of the pump or impeller. The oil leaves the second turbine as an extrusion of much

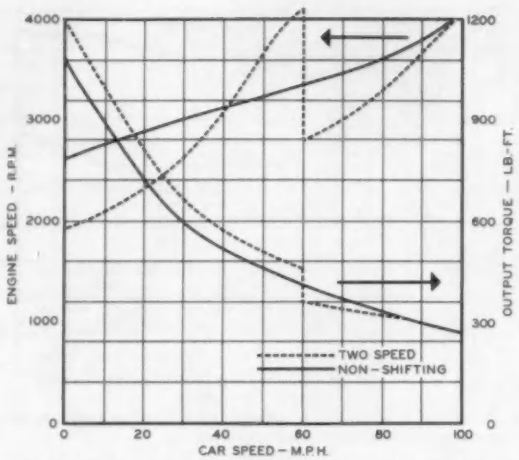


Fig. 2 — Performance comparison of a two speed transmission, three element converter, and a non-shifting five element geared converter.

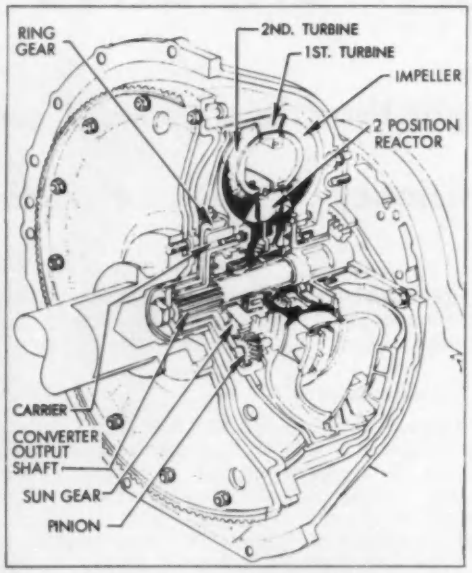


Fig. 3 — Cut-away drawing of a four element converter having one direct and one geared turbine, as shown schematically in Fig. 4.

smaller mean diameter, still having a rotational component rearward, but with less total momentum than the entering oil. The net effect is that the mechanical torque imposed upon the second turbine at stall is slightly negative. Again, it is equal to the rate of change of angular momentum of the oil as it passes through the element.

From the second turbine the oil enters the reactor. The reactor is a stationary element of the converter, grounded through a one-way clutch. The oil is given a forward component rotational velocity in the reactor, then passes on to the impeller. Mechanical torque transmitted from the reactor through its grounding shaft is negative, being opposite in direction to the rotation of the impeller.

Since the torque of the second turbine is negative at stall, the output torque of the converter is slightly less than the output torque contributed by the first turbine alone driving through the gear set.

As the converter output speed increases, the speed of the first turbine increases at a higher rate than the second turbine by a factor equal to the gear ratio. Due to the relationship of the exit angles of the impeller and the first turbine, the first turbine speed finally exceeds that of the impeller. The negative rotational component of the oil leaving the first turbine eventually passes through zero and then increases in the positive direction. Rate of change of angular momentum thus decreases . . . dropping the output torque of the first turbine.

When the angular momentum of the oil leaving the first turbine is exactly equal to that leaving the impeller, the turbine torque is zero. At this point the sun gear, which had been reacting through a one-way clutch, begins to free wheel. This allows the first turbine to continue to turn at a speed where it will not deflect the oil from the impeller.

As the first turbine deflects the oil less and less, the rotational component of the oil entering the second turbine increases. Therefore, the rate of change of momentum across the second turbine is increasing . . . and so does the torque of this turbine. The reactor torque decreases at the same time due to the reduced rearward component of the oil leaving the second turbine.

In the five element converter, shown schematically in Fig. 4, the signficant change is the positive torque of the second turbine at stall. Deflection of the oil through the first reactor accounts for this. Fig. 5 shows plots of output torques of the individual

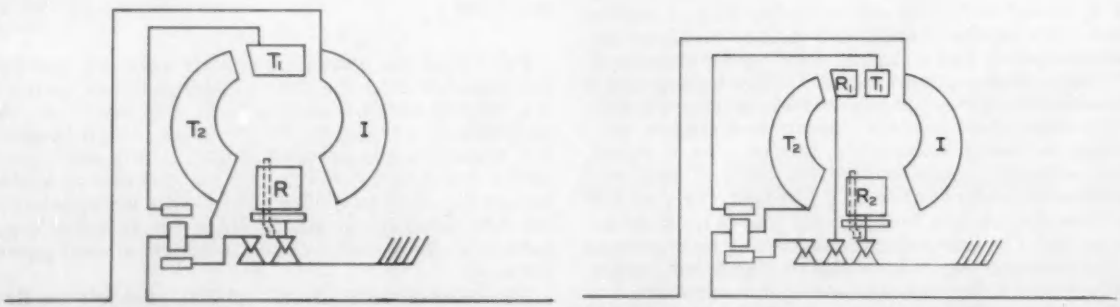


Fig. 4 — Schematic representations of a four element geared converter (left) and a five element geared converter. Each has one geared turbine and one direct turbine.

elements of these two converters — for constant input torque.

To compete with the high performance and efficiency of some of the shifting transmissions and still maintain the nonshift feature, a method of varying converter capacity had to be adopted. Otherwise, when the capacity was high enough to give pleasing light throttle starts and good highway efficiency, the full throttle performance was sadly lacking due to low engine speed and poor extension of the torque multiplication range.

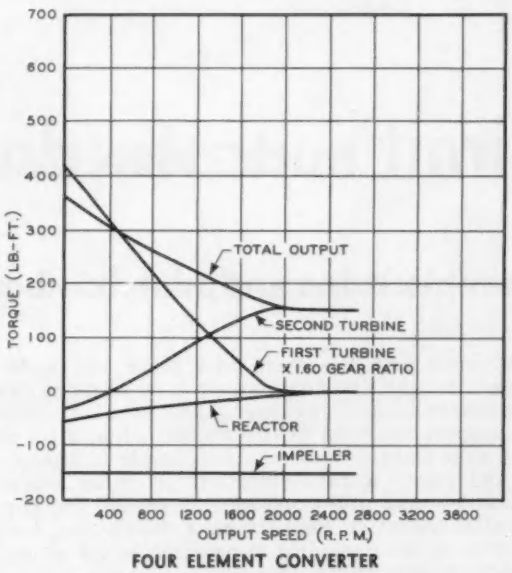
Decreasing capacity to improve performance caused light throttle "feel" and coupling tightness to suffer.

The problem is solved by a controlled change in the exit angle of the reactor immediately preceding the impeller. As the blades are shifted to the lowest angle, high deviation position, the oil passing through the reactor is redirected to have a high tangential component in the direction of impeller rotation. This increase of the angular momentum at the impeller inlet merely increases the angular momentum at the exit by the same amount if the input torque is constant. The impeller is then applying its torque to a fluid at a higher input speed. By definition, the capacity of the converter is reduced. In addition, the flow restriction introduced by the lower blade exit angles helps to reduce capacity. This occurs because the reduced flow must absorb from the impeller the same amount of energy as before, and thus has an increased terminal velocity. Therefore as restriction increases, impeller speed increases, thereby reducing capacity.

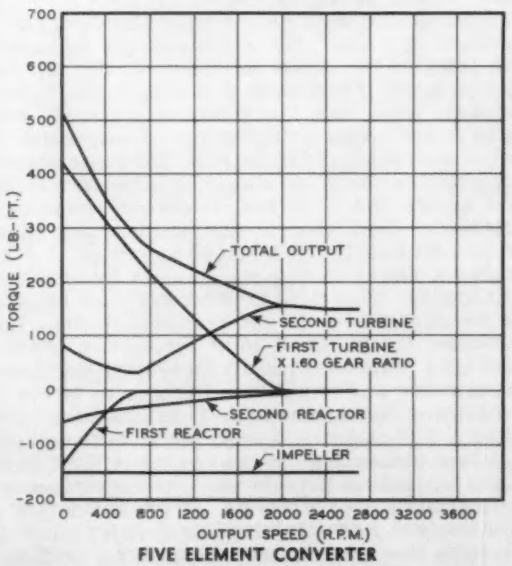
A torque converter with variable basic capacity has these main advantages:

1. In the high capacity range, the tighter converter allows start with a minimum of engine speed and fuss.
2. The high capacity converter gives a very efficient coupling.
3. In the low capacity range engine speed is allowed to increase for high performance starts, thus allowing more power input to the converter.
4. Extension of the torque multiplication range is increased to higher values of output speed in the low capacity range. Production cars with high performance engines and low axle ratios have had coupling points as high as 90 mph in this range.
5. A transition from the high capacity converter to low capacity converter and vice-versa can be very easily and smoothly accomplished. One recent production design incorporated a reactor in which the vane angle could be maintained at any position between the two extremes, as a function of throttle angle.
6. Converter capacity can easily be tailored to the peculiar torque and speed characteristics of a particular engine or to the requirements of a particular vehicle.

Overall performance characteristics for the five element geared converter of Fig. 4, in its two extreme reactor positions, are shown in Fig. 6.



FOUR ELEMENT CONVERTER



FIVE ELEMENT CONVERTER

Fig. 5 — Output torques of the individual elements of the two converters shown in Fig. 4. Input torque is constant.

To Order Paper No. 359C . . .
from which material for this article was drawn, see p. 6.

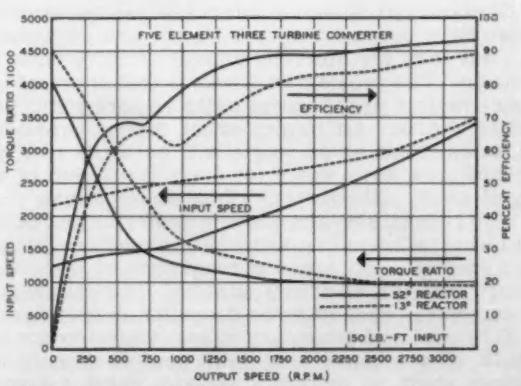


Fig. 6 — Overall performance characteristics of the five element geared converted for the two extreme positions of the reactor.

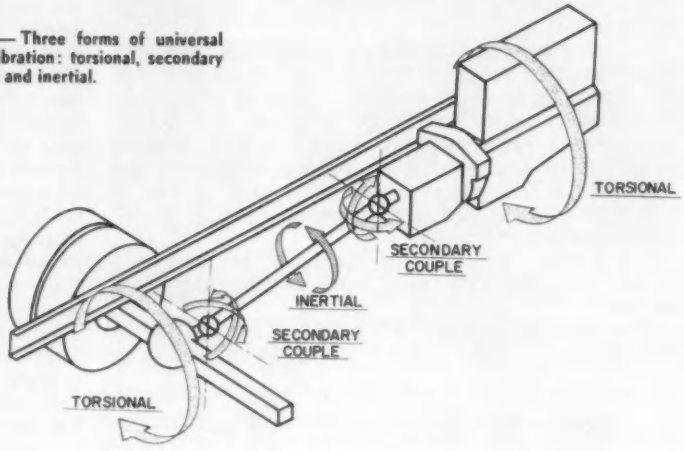


Fig. 1 — Three forms of universal joint vibration: torsional, secondary couple, and inertial.

To limit truck drive train

. . . here are simple rules and hints on how

Based on paper by

Michael C. Kaye
Freightliner Corp.

THERE is increasing awareness that drive train noise and vibration in trucks need to be reduced for the sake of the man in the cab. To be eliminated is a great spectrum of vibration that will not harm the truck, but which will annoy, distract, fatigue, or even injure the man. The various aspects of the problem include: universal joint vibration, propeller shaft critical speed, and engine mounts.

Universal joint vibration

Cardan-type universal joints are popular in truck drive lines because they are simple and economical . . . but they are inherent sources of drive train vibration. The problem in trucks is that short wheelbase tractors and tandem axles require steep propeller shafts. An output shaft driven through a universal joint at an angle will be made to speed up and slow down twice for every revolution of the input shaft. This breeds vibration problems.

Fig. 1 illustrates the three manifestations of the resulting vibrations: torsional, secondary couple, and inertial. All are a consequence of the "wobbling" rotation of driven shafting, and all produce frequencies equal to twice propeller shaft rotation.

Torsional and secondary couple vibration are the result of a mismatch of joint angles causing the output shaft to deliver a cyclicly varying torque. The torsional form affects the connected masses at either end of the drive line. The engine-transmission mass and the drive axle mass will undergo forced rotary vibrations about a longitudinal axis. Secondary couple vibration shows up as a reaction of support bearings in the transmission, drive axle and mid bearing to a rotating couple in the plane of the yoke. Rotary vibrations at these locations about vertical and transverse axes are the result. Inertial vibration appears as a fluctuating torque carried by the drive line in reaction to the propeller shaft's wobble as it is turned.

Torsional and secondary couple vibration can be cancelled in a two joint system simply by making both joint angles equal, as shown in Fig. 2. This solution holds if the input and output shafts lie in the same plane and the intermediate shaft yokes are in phase. Appropriate values of suspension deflection and axle windup must be taken into account.

In practice, there will always be some mismatch in joint angles, but a certain tolerance seems to be acceptable. As a general rule, tandem axle planes can be kept to within 2 deg of one another.

Inertial vibration is not cancelled by equalizing joint angles. This form of universal joint vibration will be stronger for longer propeller shafts. Long wheelbase trucks use 3 joint systems in order to avoid long propeller shafts with low critical speeds. The practice at Freightliner Corp. is to locate the mid bearing so as to essentially return to a 2 joint system. This is done either by placing the mid joint on a line connecting the transmission joint to the axle or by placing the mid joint on the extension of the transmission shaft axis. With the latter alternative the mid joint is intentionally offset 1½ deg from the ideal in order to prevent premature brinelling of the needle bearings in the transmission joint.

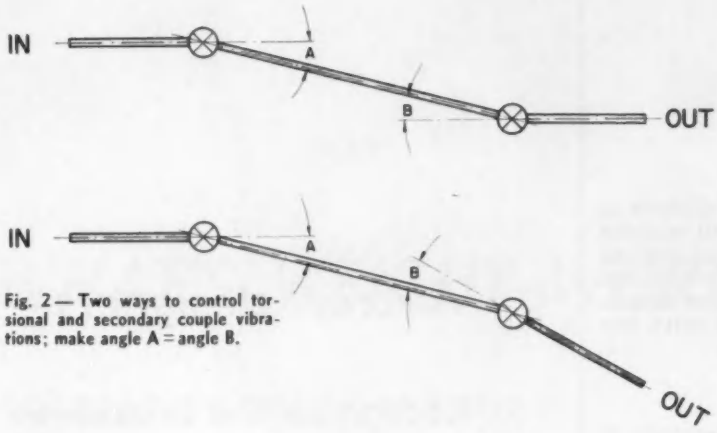


Fig. 2 — Two ways to control torsional and secondary couple vibrations; make angle A = angle B.

vibration . . .

to satisfy the man in the cab.

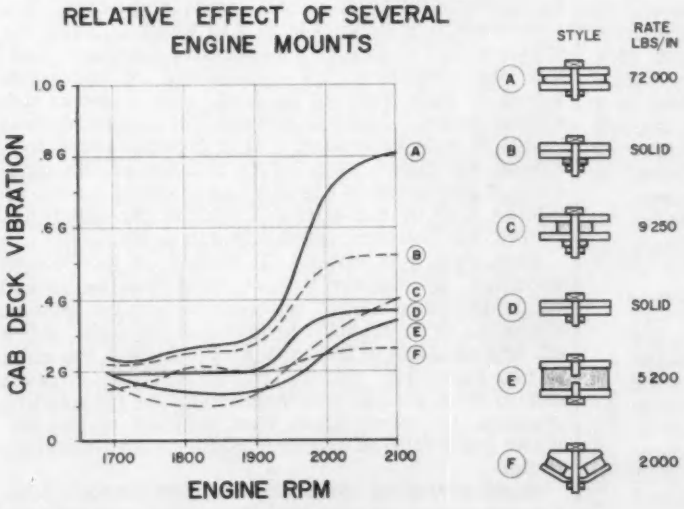


Fig. 3 — A check of vibration levels at the cab floor when different engine mounts are used shows that a piece of rubber between the engine and the frame is not always the best solution to vibration.

Propeller shaft critical speed

Critical speed can be defined as that speed which will cause a shaft to bend in excess of its strength. A rotating shaft will bend until centrifugal force acting on its distributed mass is exactly resisted by its flexural restoring force. It doesn't vibrate; it just stays bent. A propeller shaft can whip out if it is spun at a rotational speed numerically equal to its natural frequency in bending.

At sub-critical speeds, the heavy side flies out. At past critical speeds, the light side flies out, and the shaft tends to spin about its center of gravity. If the supports are not rigid, then any give at the bearing centers could add to the radius of rotation. Support deflection is a matter of response to forced vibration stemming from the whirling, eccentric shaft. Flexible supports will not affect critical speed unless they will react violently when excited at resonance.

It is fairly certain that truck drive line supports are so highly damped by friction that they will not

To limit drive train vibration

. . . continued

react at resonance with the necessary violence to have much effect on critical speed. Still, support flexure will lower critical speed somewhat, just as significant shaft imbalance would. A reasonable safety factor is allowed when the measured natural frequency is 20% greater than the safe drive line speed.

Engine mount

The engine must be mounted firmly enough, in such a way as to allow the frame to rack without placing undue stress on the engine structure. A 3-point mounting arrangement is usually employed with two mounts located at the flywheel housing, and a single support at the front of the engine block. The problem is to select the simplest design for the two rear mounts which will result in the least vibration annoyance. The popular inclination is to make the mounts soft in order to get the natural frequency of the engine on its supports lower than the exciting frequency.

Merely putting a piece of rubber between the engine and the frame doesn't always solve the problem. Fig. 3 compares the vibration level at the cab floor of the same truck for several widely used engine mounts. Apparently the "solid" engine mount is quite flexible. Besides, there is a good deal of hysteresis present. Fig. 4 is a typical example of a static measurement of hysteresis, with the engine bolted to "solid" engine mounts. Also shown is a trace of free vibration obtained by striking the bell housing with a wooden post. The natural frequency is 81 cps in this case, and hysteresis is sufficient to all but damp out free vibrations after 5 cycles.

To Order Paper No. 402A . . .
from which material for this article was drawn, see p. 6.

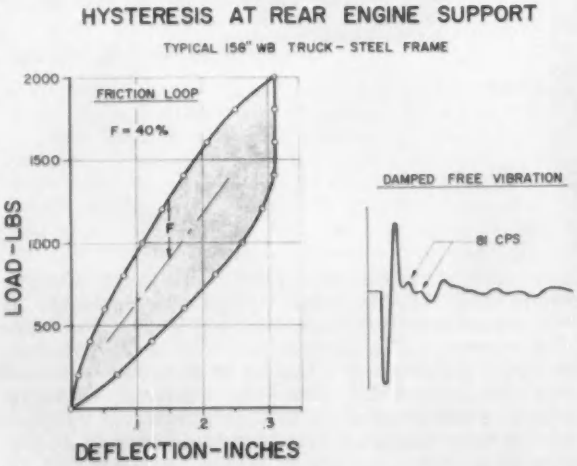


Fig. 4 — The "solid" engine mount offers hysteresis which helps damp out free vibration.

Aircraft designers—

Recognize the breakeven does not pay . . .

Based on paper by

W. A. Heacock
Douglas Aircraft Co.

LESS WEIGHT is desirable. This is a common understanding among aircraft engineers. But sometimes it is profitable to add weight. Take, for example, the design of a horizontal stabilizer leading edge requiring the installation of successive pieces of skin, each 30 in. long. Fig. 1 shows this arrangement. This was the lightest design possible — but it was expensive. This configuration consumed 200 excess man-hours because of the difficulty it presented to drilling and bucking rivets. By adding 4 lb of nut-plates a weight penalty is incurred, but the time saved is worth $1000.

Now, just how serious, in dollars, is the weight penalty? To answer this, it must first be agreed that a pound of weight removal has a value because it can be replaced with a pound of payload. After all, the airplane is basically a carrier, and the more it can carry the better. If the airplane is made lighter by a pound, this weight can be replaced by payload. It seems, then, that the cost of the airplane per pound of payload would be an important factor.

Suppose that in the above case the airplane costs $98 per pound of payload. Replacing 4 lb of payload with nut-plates involves a penalty of $392. Apparently the nut-plates are worth the added weight since there is a net gain of $608. The original design placed too a high a value on the weight saved by not using the nut-plates. Whereas weight is only worth $98/lb, the 4 lb that might have been saved would have cost $1000/4, or $250/lb.

Even an increase in the airplane cost can be justified on the basis of cost per pound of payload. Consider an airplane costing $585,000 which can carry 1600 lb of payload. The cost to the customer is $366/lb. To save a pound by using titanium bolts

WHAT'S WEIGHT WORTH?

point, where weight reduction

and stick to it.

Fig. 1 — Adding weight saves money by saving time. If the time saved is worth more than the reduction in payload, the heavier, but easier to build design, is best.

costs approximately $120. If payload is increased in this manner by 100 lb, the cost increase is $12,000. The cost to the customer per pound of payload is now $597,000/1700 = $350; which is $16 cheaper than before. Although the cost per airplane has been increased, an over all improvement has been achieved and the over all fleet cost does not increase. The increased payload capacity of the fleet means that a smaller fleet can accomplish the same mission as a larger one. A smaller fleet brings savings because of the reduced amount of airplanes, personnel, spares, maintenance, and facilities. In other words, efficiency is greater. If the money invested in the weight reduction program equals the money saved by eliminating the requirement for a larger fleet, then the program is worth while.

The cost per pound of payload is rapidly increasing with the refinement in the aviation industry. In 1960, the average worth of weight reduction was close to $400 and increasing at the rate of $21 per year. Obviously, the price we must be willing to pay for weight reduction must be re-evaluated for each new contract.

Some rules to follow in reducing airplane weight are:

1. Before choosing between two designs, both designs must be proved adequate.
2. The effects of adding or removing weight must be applied to the entire airplane rather than a specific part. An ounce added to the elevator may add 8 oz to the balance weights.
3. The entire airplane should come under consideration. Otherwise, obviously overweight designs will exist side by side with over-refined designs.
4. Buying the heavier of several products will result in having to highly refine other parts to equalize the airplane.
5. Tighter tolerances should be enforced. There is a large amount of weight in small increments. Milling, sanding, or selective segregation of sheet can eliminate approximately .007 in. of excess material from large pieces of 1/16 in. thick sheet stock. On two wing skins of one small airplane this amounts to $7800 worth of weight reduction.

   All forgings carry excess weight because of closure and mismatch tolerances. Machining all over is the only way to remove this weight. When weight is valued at $300/lb, this should be done.
6. A limit should be set on overstrength margins. A vast quantity of small parts, each a little overstrength, adds up to an appreciable weight. It is all too common to change fittings from aluminum to steel for a "panic button fix" after failure in test. This often results in extreme overstrength.
7. Modernized design results in the largest weight improvement. In this category are found modern high-strength materials and lightweight fasteners. Better packaging of electronic gear, minaturization, higher pressure hydraulic systems . . . all of these are examples of modernized design. Higher voltage systems too, allow savings in conductor weight.

To Order Paper No. 421A . . .
from which material for this article was drawn, see p. 6.

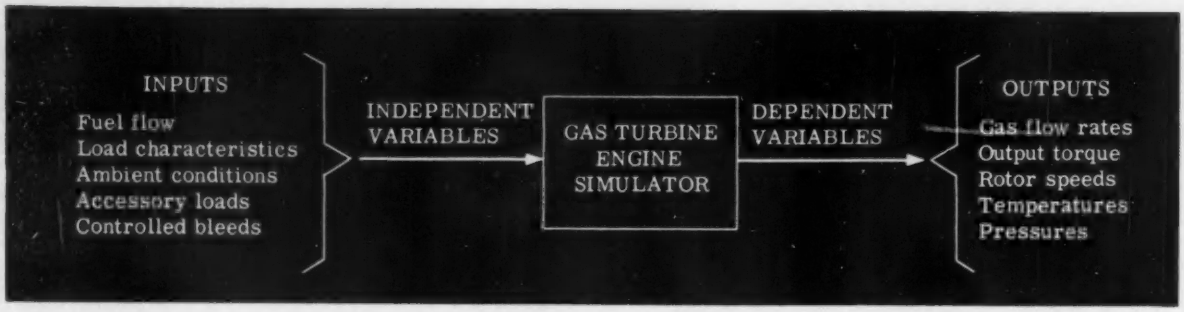


Fig. 1 — **Input and output variables** of a typical gas turbine engine simulator.

Computers help design turbine

Based on paper by

V. L. Larrowe and M. M. Spencer
Institute of Science and Technology, The University of Michigan

A GAS TURBINE ENGINE CONTROL can be designed even before the engine is available, and "debugged" without actually building the control. All this is possible by using analog computers which can simulate both the engine and the control.

In the hands of the control designer the simulator becomes a valuable tool for determining engine operating characteristics and coefficients and curves needed for his control design. Not only is this practice considerably less expensive than running the actual engine, it also eliminates the danger of engine damage caused by over-temperature or surge conditions. The simulator will indicate such harmful conditions without suffering ill effects.

The analog computer, when used as an engine simulator, can perform any tests which could be performed on the actual engine . . . and many which could not. The manner in which most of these tests are performed is analogous to that which would be used on the actual engine. For example, in order to obtain steady-state engine performance data, the various input variables would be set to desired values by setting the appropriate potentiometer dials on the computer. Fig. 1 shows input and output variables for a typical simulator. After the input variables have been set, enough time is allowed to permit the computer to reach a "steady-state" operating condition, and voltages corresponding to the output variables are measured. The data can be obtained in digital form by using a digital voltmeter and printer which will read and print the value of the voltage representing the desired output variable.

Steady-state engine performance may be obtained directly in graphical form by using servo-driven X-Y plotters connected to the engine simulator. A plot of fuel flow versus rotor speed is obtained by connecting the voltage representing fuel flow to the "Y" input of the plotter, and the voltage representing rotor speed to the "X" input. It would be necessary to lift the plotter pen from the paper whenever an adjustment is made in the fuel flow, and lower the pen after the transient has died out and the rotor speed has reached its new value. Otherwise, the pen would trace out the path followed by the variables in going from initial to new values. The resulting graphical steady-state data will therefore be a series of points on the actual steady state curves.

If the pen is allowed to remain on the paper when one or more of the input variables is changed, the resulting plot can often be illuminating. Even when such data are not directly applicable to control design they may help the designer develop an effective philosophy for the control system.

A more useful quantity to the control designer is, perhaps, the time response of the engine to step changes in input variables. The engine's response to such step inputs may be explored by using a switch or relay to introduce step changes in the voltages representing these inputs on the engine simulator, and reading the outputs on an electro-mechanical oscillograph. If desired, the amplitude and phase response to sinusoidal driving functions of various frequencies on one or more of the input variables may be measured.

The control designer is usually interested in finding the maximum permissible value of fuel flow as a function of rotor speed which will keep the engine within surge and temperature limits. The engine simulator can easily be made to indicate when conditions are appropriate for surge, or when any tem-

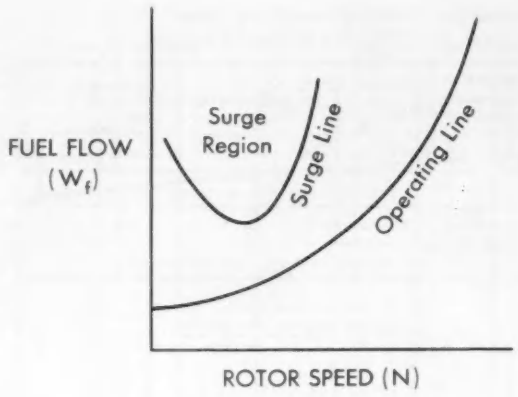


Fig. 2 — **Operating and surge line** of a simple turbojet engine.

engine control

peratures or other variables exceed specified limits. In investigations of this type it has an added advantage over using an actual engine. With the computer the rotor speed may be held at any desired value by placing the computer in the "reset" mode of operation. In this mode all the elements of the computer work except the integrators, so the output of each integrator is equal to an "initial condition" voltage which is fed into that integrator. Thus although transient operation is usually necessary to produce surge in an actual engine, surge conditions may be obtained in the computer statically. For example, if the value of fuel flow needed to produce surge at some specific rotor speed is desired, it is only necessary to set and hold rotor speed at the specified value, and then increase fuel flow until surge is indicated.

After the operating line and the surge region of an engine are determined, as shown in Fig. 2, maximum acceleration capability may be found. Since the vertical separation between the operating line and the boundary of the surge region represents the permissible increase in fuel at a particular rotor speed, it determines the maximum rotor acceleration possible at that rotor speed. If a function generator is connected to the engine simulator in such a manner as to limit accelerating fuel flow to just below that which would cause surge, the time required for acceleration from any speed to a higher speed may be found.

In a similar manner deceleration performance can be measured. In this case fuel flow reduction is limited by the possibility of "flame-out." If the minimum fuel-to-air ratio needed to insure reliable burner operation is known, a curve representing the minimum fuel flow needed to give this ratio may be determined with the simulator. Such a curve defines the upper boundary of the "flame-out" region. When plotted below the operating line it shows how low fuel flow can be allowed to drop. Again, with the aid of a function generator, the simulator can be used to find minimum deceleration time between any two rotor speeds.

The control designer usually would like to know how sensitive certain engine variables are to changes in other variables. The sensitivities may be determined on the simulator, much as they would be on a test engine. Suppose that the sensitivity of the turbine inlet pressure, δ_5, to changes in fuel flow, W_f, with rotor speed held constant. Starting with the simulator operating dynamically at the value of rotor speed for which the sensitivity is to be determined, the computer is placed in the "hold" mode. In "hold," each integrator immediately halts its integration operation and its output voltage remains at the value which was present before the computor was switched to this mode. Thus a problem can be stopped at any instant and the values of all the variables which were effective at that time may be read out. Now, since the rotor speed integrator cannot operate the rotor speed cannot change. If a small change is made in the voltage representing W_f, the resulting change in the voltage representing turbine inlet pressure can be measured. These voltage changes can be converted into corresponding changes in the variables they represent.

The engine simulator is also useful for testing control designs. Suppose that desirable characteristics and philosophies have been established. The control system thus specified may be simulated by additional analog computing equipment and connected to the engine simulator. Tests may then be run on the resulting controlled-engine simulator to see if the control system is satisfactory. If modifications are then required they can be made, until the desired performance is attained.

After the actual control system has been constructed it is possible to connect it to the engine simulator with suitable transducers for preliminary performance tests, in case a test engine is not yet ready.

To Order Paper No. 398A . . .
from which material for this article was drawn, see p. 6.

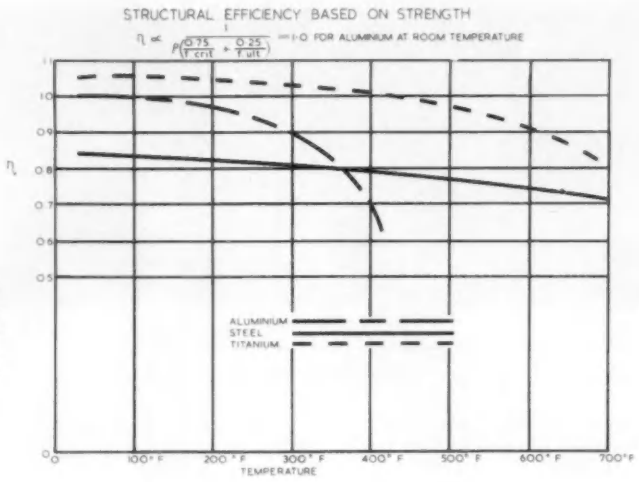


Fig. 1 — **Based on specific strength,** at temperatures over 375 F the selection of titanium or steel becomes marginal. Where creep deformation becomes a parameter steel may have an advantage.

British View Materials for Supersonic Transport

. . . and Mach 2-3 aircraft. Metals must be heat-resistant to 700 F.

Based on paper by **P. F. Kiddle**
and
P. J. McKenzie
Hawker Siddeley Aviation Ltd.

BRITISH ENGINEERS are investigating materials for aircraft structures operating at temperatures up to 700 F. This is one part of a design study of the supersonic transport and aircraft in the Mach 2.0–3.0 range. Materials being examined include: Aluminum, Titanium, Steel, and Ultra-high tensile steels.

Aluminum

Aluminum is a structurally attractive material for sustained supersonic flight up to 250 F and up to 350 F for supersonic "dash" conditions. Basic material cost and the existence of fully developed production techniques favor the exploitation of aluminum to these limits.

Current interest in the supersonic transport has provided added incentive to improve the elevated temperature performance of existing aluminum alloys. The main problem is with sheet and plate materials — since it is the outside skin which reaches maximum flight temperature due to kinetic heating, and the properties of sheet at elevated temperatures are usually much lower than that of bar or forging stock of the same composition. Optimum use of heat treatment and grain size control of aluminum alloys are needed to achieve superior elevated temperature properties.

Titanium

Titanium has some very attractive mechanical and physical properties at room temperature and to 550 F. In fact, apart from specific stiffness, it would appear to be the logical choice for any structure operating in this temperature range. However, in England, the use of titanium has often been rejected. The two major reasons for this are the high initial cost of the material and fabrication difficulties.

Recently, the double heat-treatment titanium alloys have aroused interest as materials combining elevated temperature performance with fabrication potential.

Steel

Based on specific strength, Fig. 1 shows that at temperatures over 375 F the selection of titanium or steel becomes marginal, and where creep deformation becomes a design parameter steel may have an advantage. Fig. 2 shows that steel is more efficient

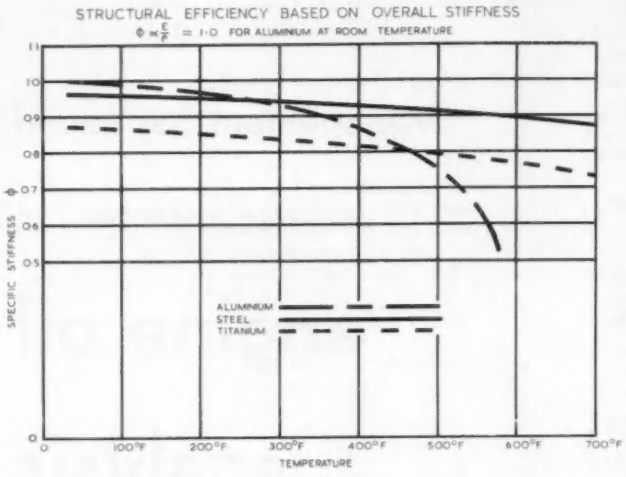


Fig. 2 — **Steel is more efficient** than aluminum and titanium over 275 F where design is a function of stiffness.

over 275 F where design is a function of stiffness. To obtain the required structural efficiency, the outer structure of a supersonic transport operating at the higher temperature range will be manufactured largely from thin gage (0.008–0.020 in.) sheet. In view of the particular environmental conditions, this would indicate the use of a "stainless" type material. The types of steel which warrant consideration are:

1. Martensitic stainless steel
2. Austenitic cold rolled stainless steel
3. Austenitic precipitation-hardening stainless steel
4. Semi-austenitic precipitation-hardening stainless steel

The martensitic stainless steels are based on a 12% Cr composition. These materials tend to provide the highest mechanical properties of any of the stainless steels from 0–600 F, and if static strength combined with reasonable corrosion resistance is an overriding design criterion, this class of stainless steel has much to offer. The higher modulus value of this material is also attractive for many applications. The main disadvantages of these materials are those associated with fabricating large thin skins, that is, the heat-treatment cycle is incompatible with an end product exhibiting the necessary controlled shape and surface finish. The difficulty associated with the alternative approach of forming the material in the hardened and tempered condition is obvious.

To achieve maximum formability, there has been a tendency to use unstabilized versions of cold rolled austenitic stainless steel, although in a structure using welding techniques as the prime joining medium such a material has considerable disadvantages. These materials usually exhibit an elongation and proof stress trough around 400 F and also suffer severe Bauschinger effects due to cold work.

The austenitic precipitation hardening stainless steels are not used much in England, but increasing interest is being shown, particularly for temperatures of 700 F and over.

The semi-austenitic precipitation hardening stainless steels are most interesting for use on projects such as the supersonic transport and much development effort has been put into these materials in recent years. These materials are austenitic steels which under certain conditions transform to martensite and contain elements such as copper which provide a precipitating phase. In the annealed condition the material is fully austenitic and the heat treatment cycles which may be applied to obtain optimum properties are:

1. Anneal at 1920 F. Transform by heating to 1380 F. Precipitate at about 930 F.
2. Anneal at 1920 F. Cold rolled and mill transformed at 1530 F. Sub-zero cool to complete transformation. Precipitate at about 930 F.
3. Anneal at 1920 F. Sub-zero (–94 F) transform and precipitate at about 930 F.

Transformation by cooling from 1380 F is embarrassing due to the adherent scale formed and the volumetric expansion associated with the austenite-martensite transformation, equivalent to a linear expansion of 0.004 in. per in. This could prove troublesome with very thin skins. Thus the two heat treatment cycles most attractive to aircraft manufacturers are:

1. Receipt of material in the soft condition — this condition being necessary to achieve severe forming operations. After forming, the user then has to deep freeze (–94 F for about 4 hr) to complete the transformation followed by a precipitation or tempering treatment at about 930 F.
2. Receipt of material in the mill transformed condition so a limited amount of work can be carried out followed again by a tempering treatment. The selection of a suitable precipitation temperature is dependent on the optimization of such properties as tensile strength, corrosion resistance, ductility, and the degree of fabrication required. While higher properties may be achieved by using lower tempering temperatures, there has been a tendency to use materials tempered at higher temperatures to get a better balance of properties.

The volumetric change accompanying transformation can provide two troublesome areas. First, for assemblies formed in the soft condition, subse-

quent heat treatment will lead to distortion. Second, local phase instability around weld areas can give rise to stress concentrations or distortion. However, stress distortion and loss of strength may be counteracted by cooling the weld zones and initiating transformation in a controlled manner.

In manufacturing a double skin corrugation, the following sequence could be used:

1. Material supplied in mill transformed condition.
2. Sheets formed to contour.
3. Sheets heat treated at about 930 F.
4. Corrugation material formed in mill transformed condition or possibly in austenitic condition, in which case sub-zero transformation is necessary.
5. Corrugation heat treated at about 930 F.
6. Skins joined to corrugation by welding.

The feasibility of stretch forming complete panels presents an interesting possibility. Although stiffness directionality would restrict the possibility of double curvature, the economic advantage could be considerable. One approach might be to provide some "in-filling" material capable of being removed after forming. This filler could either have a low flow temperature or be readily soluble in some solvent.

Vacuum melting of these steels might provide better ductility and crack propagation characteristics.

Ultra-High Tensile Steels

An indication of the possible advantages in using ultra-high strength steels is that its use in the undercarriage and back up structure of a large transport would result in a weight savings of about 10% or 600 lb. The basic properties required of the material are:

0.1% Proof Stress	225,000 psi
Ultimate Tensile Strength	300,000 psi
Elongation, minimum	10%

While there are a whole range of steels which may lay claim to consideration for use at high strength levels in the form of large forgings, primary interest is centered around 5% Cr steels. The attraction of these steels is largely due to the hardenability associated with a high tempering temperature. This enables the designer to achieve the necessary condition of a tempering temperature higher than the service environmental temperature, and at the same time provide high residual stress relief. Present investigations on these steels are concentrated on finding the advantage of vacuum-melting over air melting, investigating the problem of hydrogen embrittlement and the properties of protective coatings, and optimizing welding conditions to provide sound joints in large sections.

Tests reveal that a tempering treatment of around 1100 F is required for optimum mechanical properties. A double temper of 980 F for 2 hr and 1060 F for 6 hr following normalizing and hardening at 1920 F provide good optimization of properties with reduction of area and elongation values being significantly less for air-melted stock than vacuum-melted stock.

To Order Paper No. 420A . . .
from which material for this article was drawn, see p. 6.

Management has sound maintenance tool in engine oil analysis

Based on paper by

Capt. R. S. Stewart

Bureau of Naval Weapons, Department of U. S. Navy

OIL ANALYSIS provides an inspection technique to develop lower maintenance costs as well as a reporting system indicating fleet condition and cost trends. It is independent of errors associated with the cost reporting responsibilities of line supervisors. It is impartial; it bases on factual experience, and its cost runs 50¢ per vehicle per month.

Fig. 1 shows what changing the interval between preventive maintenance inspection does to total maintenance cost. The total includes the cost of down time of vehicles scheduled for inspection and repair and unavailable for assignment. In this study the inspection routine remained constant, and each curve represents a separate fleet. The effect of higher utilization is demonstrated, but regardless of utilization, the minimum total cost occurs when P.M. cost falls between 45–60% of total cost.

Having established this cost fact, attention can be directed to direct labor expended in the areas of work generation and work done in search for further cost reductions. In many ways, work generation policies and procedures have a greater influence on maintenance costs than the best of controls over productive effort. Note (in Fig. 1) the effect of under-maintenance and over-maintenance on the total cost per mile. Both are the result of inadequate inspection techniques.

Forget the statistics

In the earlier days of applied P.M., frequency and detail of inspection were based on casualty experience. At today's prices, it is best to forget the statistics and develop a technique which will tell as accurately and inexpensively as possible the extent of repair and adjustment needed to make assemblies

Table 1 — Cost Comparison Showing Reductions Realized With Oil Analysis

Item	Year Ending March 31, 1956 No oil analysis	Year Ending March 31, 1958 With oil analysis
1. Average number of vehicles	721	592
2. Number engine inspections	4762	257
3. Number oil samples taken	0	1897
4. Number repair orders	936	257
5. Number filters replaced	496	464
6. Number oil changes	2458	1020
7. Inspection cost	$10,100	$ 550
8. Repair cost	6,680	2,028
9. Filter replacement cost	982	919
10. Oil change cost	4,470	1,854
11. Sampling cost	0	3,657
12. Total cost	22,232	8,018
13. Cost per mile	$0.00483	$0.001797
14. Cost per vehicle	$30.84	$13.54

function properly. The economy of replacement versus repair can then be readily determined.

At the time of reviewing diagnostic methods, a report was received of an experimental oil analysis program being conducted at six large West Coast installations. It indicated that only one engine in every seven inspected actually required adjustment or repair, whereas our overall record showed adjustment and repair on three out of every five vehicles inspected, with more than 40 min required for each inspection.

Oil analysis successful

Before adopting oil analysis as a tool it seemed wise to try it in a large installation in Washington, D.C. This was done, commencing 1956. Under test control procedures, engine repairs were authorized strictly in accordance with the oil analysis report. Scheduled engine inspection was limited to a visual check for the purpose of noting leaks, and an audio check for detecting obvious malfunctioning. A calculated risk was taken that there might be engine failures which would have been anticipated under previous inspection programs. Five years experience proved the risk to be slight. Of the 3000 vehicles included in the test program, only two engine failures occurred which might have been detected by previous, expensive procedures, and these were doubtful. No otherwise avoidable costly repairs were reported, although doubtless some were experienced.

Table 1 shows the cost reductions obtained at the Washington installation over a 24-month period. The principal cost reductions came from decreased inspection, repair, and lubrication costs. Maintenance costs are continuing at about the same level. Presumably a minimum engine maintenance cost has been reached for this particular fleet at its particular level of utilization as far as inspection policy is concerned.

Points to remember

Where a department head has used an analysis summary report as a management tool to control fleet condition and cost, the program has been successful. Where management has been disinterested, the program has usually been ineffective.

It is impossible to study cost trends in the maintenance of engines unless P.M. costs can be identified and their relation to total cost established.

It is equally impossible to determine if any inspection technique will develop savings until it has been applied to a particular fleet and the cost trends studied over a period of time.

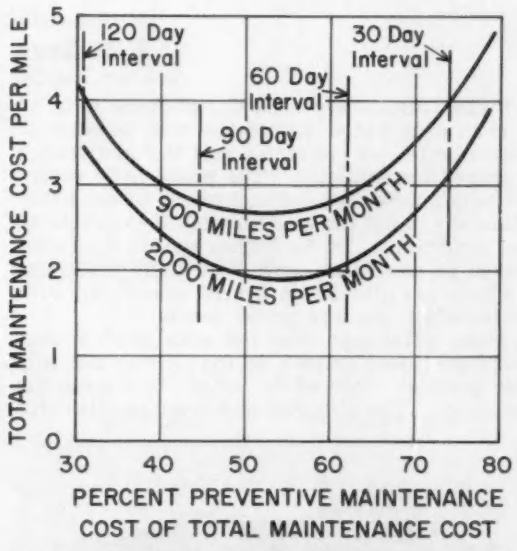


Fig. 1 — Relationship of preventive maintenance cost to total maintenance cost. Both under- and over-maintenance influence cost per mile and both are due to faulty inspection technique.

To Order Paper No. 406A . . .
from which material for this article was drawn, see p. 6.

Twin Disc power shift

. . . combines the flexibility of the torque converter of the direct geared transmission,

Based on paper by
J. B. Snoy
Twin Disc Clutch Co.

THE TWIN DISC power shift transmission (Fig. 1) has been designed to utilize the best features of the hydraulic torque converter and the multirange direct geared transmission. The broad ratio coverage of the converter is used exclusively in the lower speeds mainly to get the load moving or to negotiate unusual conditions. In the higher speeds the ratios are spaced as closely as some stick shift transmissions, which permits direct geared operation, with its greater efficiency and power availability.

The great advantage over the stick shift is that the ratios are power shifted, so that it requires only the now familiar "flick of the wrist" to engage the various ratios. The clutches which accomplish this shifting are hydraulically operated and designed to give extremely fast but smooth engagement.

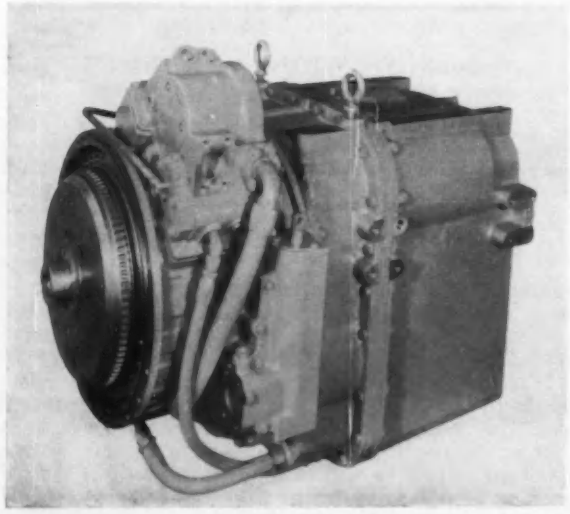


Fig. 1 — First model of Twin Disc power shift transmission has five speeds forward, one speed in reverse. It was designed primarily for off-highway trucks and self-propelled scrapers with engines of 425-hp net rating.

A performance curve of an actual vehicle installation is shown in Fig. 2. Note that the wide spread of ratios in the lower gears is covered by the wide utility ratio of the converter, whereas the higher ratios are spaced closely enough to permit 100% operation with the converter locked up and the engine geared directly to the ground.

A building block diagram of the design is shown in Fig. 3. The transmission consists of three main sections — the converter, the gearbox, and the transfer case. These sections are designed so that all three or the gearbox and either of the other two can be assembled as one integral unit, or each can be installed separately with a driveline between each one. This provides good adaptability for driveline and vehicle configurations.

The torque converter section contains all the hydraulic components except the range clutches, the range selector valve, and the oil sump, which are on or in the gearbox. Two openings for engine-driven power take-offs are provided on the converter housing. Two sizes of converters with several absorption capacities in each size can be provided. The lockup clutch can be omitted for some applications, such as end loaders, pusher-dozers, and locomotives, and a hydraulic retarder is available.

The gearbox contains the change gearing with the attendant clutches and selector valve. It is a five-center countershaft design with input and output being on the same centerline. The three clutch shafts are arranged about the input-output centerline, as is the reverse idler shaft. One clutch shaft carries the low forward and reverse ratio. The other two shafts carry the other four forward ratios.

One of the advantages of the countershaft design is the relative ease of altering ratios. This is being done in order to accommodate the requirements of various vehicles and at present four sets of ratios are available. The important thing is that, in contrast to a planetary design, only single gear meshes are affected and a ratio change usually requires no more than a new gear forging.

transmission . . .

with the economy and performance

according to its builders.

THE accompanying article is the second in a series on new transmissions that are being developed for heavy-duty vehicles, such as farm tractors, off-highway trucks, and earthmoving equipment.

The October Journal (p. 55) discussed the MF — 65 hydraulically shifted transmission developed by Massey-Ferguson for farm tractors.

Next month's article will describe the Caterpillar powershift transmission developed for track-type tractors, rubber-tired tractors, and the Traxcavator loader.

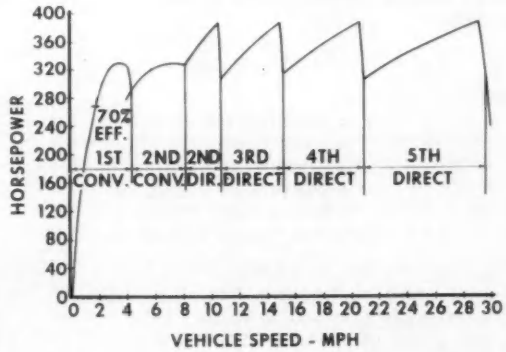


Fig. 2 — Performance curve of an actual vehicle installation.

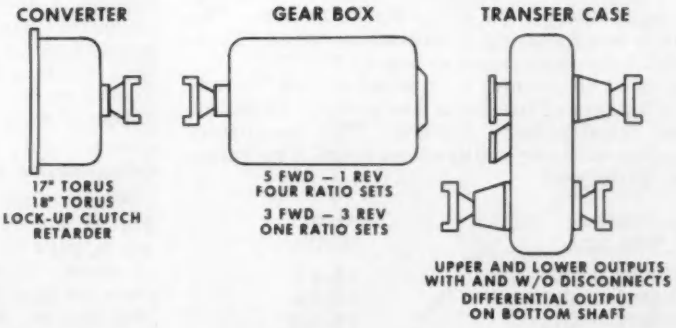


Fig. 3 — Building block diagram of design shows transmission consists of three main sections: converter, gearbox, and transfer case.

Locomotives, railcars, end loaders, and pusher-dozers require the same number of speeds in both forward and reverse directions. These requirements are met by inserting an idler gear in the input train of one of the forward countershafts and reversing its direction of rotation. This results in a gearbox with three forward speeds and three reverse speeds.

Locomotives, end loaders, pusher-dozers, and oil field and four-wheel-drive trucks require outputs that are displaced from the engine centerline. It is for these applications that a transfer case is provided.

A simple transfer case is not enough, so a number of suboptions must be provided for this major option. Four-wheel-drive trucks must have a differential. Front end loaders must have a fore-and-aft output with a disconnect on the end toward the engine. Locomotives may take a single- or double-ended output. Oil field trucks need a lower output to the wheels and an upper output to the cementing pumps with a disconnect on each one.

A cross-section of an integral transmission is shown in Fig. 4. The hydraulic torque converter, the gearbox, and the transfer case are connected

together as one unit, but the lines at which they are split for independent mounting are easily identified.

Case construction

The main housing sections of the transmission are cast iron with a rather unique manner of channeling hydraulic oil to the clutch shafts. This is shown in the open view of the main case in Fig. 5. These internal oil lines consist of 0.500-in. diameter steel tubing pressed into reamed holes and then expanded tightly into the hole from the reverse side with tube expanders.

Gearing

Also shown in Fig. 5 is the gearing in the clutch section of the gearbox. All gears in the transmission are spurs. The engineers have been accused of making gears this way because spurs are less tedious to calculate and, even if true, this can be defended, for it naturally follows that anything that is tedious to engineer is tedious to manufacture and to inspect. But there are other more important reasons for using spurs, for they have no theoretical thrust and therefore the housing ends and the bulkhead which carry the bearings require rigidity transversely only and not axially. The lack of thrust also permits the use of small thrust washers adjacent to the clutch gears and the utilization of lipped roller bearings for location and support. The roller bearings provide the greatest possible bearing capacity in the available space with location and what thrust that does exist being accommodated by the bearing lips.

A question that might be asked when considering the spur gears is, "What about noise?" Actually, gear noise in the vehicle is hardly noticeable. The tooth form on all gears is modified somewhat. Typical modification curves are shown in Fig. 6.

One gear of each mesh is crowned slightly to prevent end loading of the gears due to shaft deflection or other misalignment factors. The amount of crown varies with the width of the gear. The values used are as follows:

Crown Tolerance	Gear Width
0.0005–0.0008	1.0–1.5
0.0008–0.0011	1.5–2.5
0.0012–0.0015	2.5–3.5

All gears also have a 25-deg pressure angle to obtain high strength in bending. This high pressure angle is more difficult to manufacture and theoretically should be more noisy than the 20-deg pressure angle but the increased strength results in a unit of smaller size. However, as mentioned, noise has been no problem and, in the transfer case, the gears are operating under load at a pitchline speed of 10,000 fpm.

Wherever possible, drive from gear to shaft is accomplished by means of a shrink fit and a key, with the greater portion of the torque transmitted through the shrink fit. Splines are used only where necessary for assembly purposes.

A typical shrink fit setup is: bore 2.8757–2.8765, shaft 2.8800–2.8795, resulting in a 0.0030–0.0043 tight fit.

Bending stresses

Since this transmission operates behind a torque converter, it is designed around two points: converter stall, which is the maximum stress condition; and an arbitrary durability condition of 1.25 torque ratio and 0.7 speed ratio.

Bending stress is limited to 30,000 psi at 1.25 torque ratio and 80,000 psi at stall. Generally, combined shaft deflection slopes through the gears do not exceed 0.002 in./in. at the 1.25 torque ratio condition. The gear bending stress is calculated with load at the highest point of single tooth contact.

Stress concentration, mal-load, and velocity factors are not included. Idler gears are stressed to only 70% of these values, due to the effects of load reversals. Where gears operate in direct mechanical connection to the engine, a stress limit of 30,000 psi at maximum engine torque is used.

The formula for calculating bending stress is the familiar:

$$S_B = \frac{T \times \mathrm{DP}}{F \times Y \times \mathrm{PR}}$$

where:

S_B = Bending stress, psi
T = Gear torque, lb-in.
DP = Diametral pitch
F = Gear face width, in.
Y = Tooth form factor
PR = Gear pitch radius, in.

Fig. 7 shows the Y or Lewis form factor for standard gear teeth of the type used in this transmission. As stated earlier, bending stress limits are set at the highest point of single tooth contact and this calculation requires use of the Y' factor. A series of layouts of gears with mating gears of various sizes indicated bending stress with load at the highest point of single tooth contact to vary between 60 and 70% of stress with the load at the tip of the tooth. Therefore, we assume an average value of 65% and obtain Y' as shown by the formula in Fig. 7.

Compressive stress

A curve has been used based on 4×10^7 cycles of life at 200,000-psi pitchline surface compression stress, with life varying inversely as the tenth power of stress. This is conservative, as evidenced by experience and the allowable stress could probably be 10% higher. No allowances for mal-load or velocity factors are included. The formula used for calculating surface compressive stress is:

$$S_c^2 = \frac{10.5 \times 10^6 \times F_c \left(\frac{1}{\mathrm{PD}_1} + \frac{1}{\mathrm{PD}_2} \right)}{F \times \mathrm{Sin}\ \phi}$$

where:

S_c = Compression stress, psi
F_c = Base circle force, lb
PD_1 = Driver pitch diameter, in.
PD_2 = Driven pitch diameter, in.
F = Gear face width, in.
ϕ = Pressure angle, deg

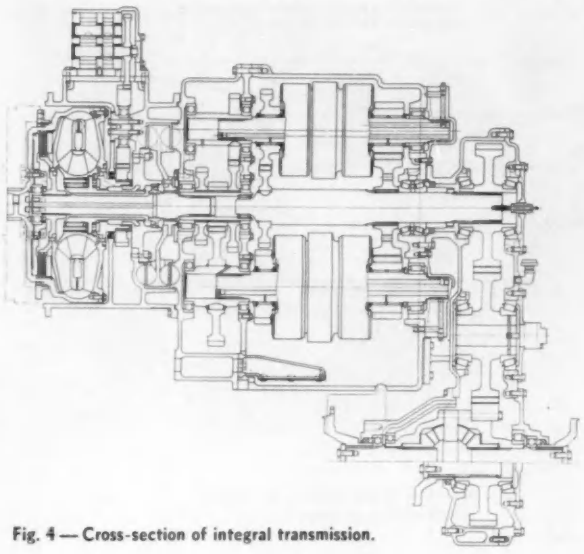


Fig. 4 — Cross-section of integral transmission.

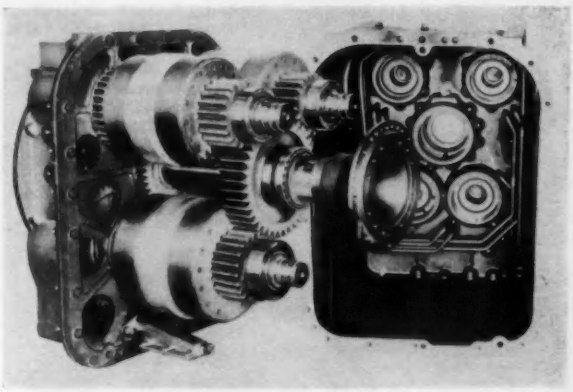


Fig. 5 — Open view of main case.

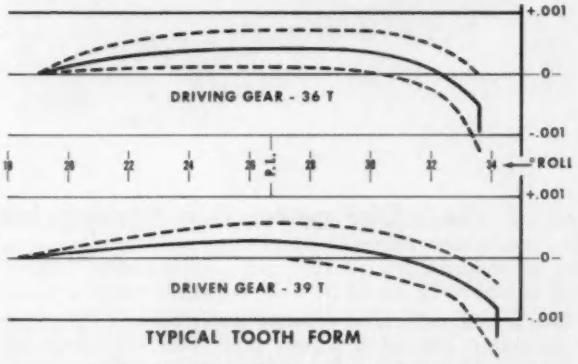


Fig. 6 — Typical modification curves for gear teeth.

Clutch design

The gears, shafts, bearings, and housings are familiar articles to all mechanical engineers, but the heart of the gearbox is the duplex clutch, which engages the various gear sets. Only rotating clutches are used, which is a necessity in a countershaft-type transmission. However, rotating hydraulically operated clutches have a number of disadvantages, which have been a problem to designers in the past — and the larger the clutch, the greater the problem. This had led to efforts to design transmissions with no rotating clutches and the elimination of rotating clutches being considered a progressive step by some engineers.

The first problem here is that a rotating piston filled with a liquid will develop an axial force due to centrifugal effects on the liquid that is proportional to the fourth power of the piston diameter and the second power of its rotational speed. The formula for this force assumes that the oil is fed at the center of rotation and that the density of the fluid is 0.032 lb/in.^{3}. The force is directly proportional to density if other densities are to be considered:

$$F = 714 \times 10^{-9}\, N^2\, R^4$$

where:

F = Force, lb
N = Rotational speed, rpm
R = ½ diameter of piston, in.

On a 10-in. piston rotating at 2100 rpm, this force is 1970 lb. To design a spring to disengage this clutch at speed is a formidable task, so the usual solution is to provide some type of "dump valve" that is pressure and speed sensitive, such that it will dump all oil from the piston cavity and the supply passages if an outside pressure above a certain level is not applied. This solution creates another problem, which will be discussed later.

Because of the centrifugal effect, a rotating clutch

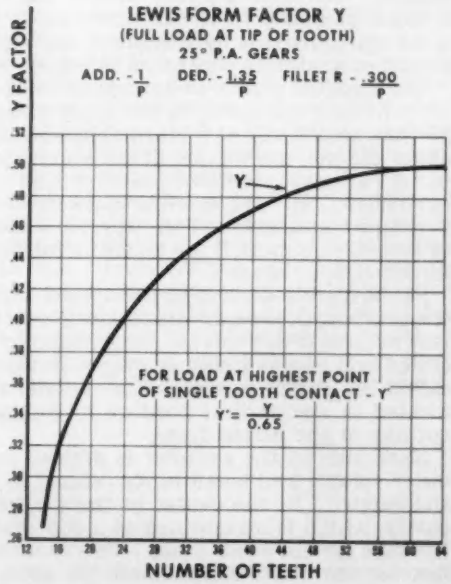

LEWIS FORM FACTOR Y
(FULL LOAD AT TIP OF TOOTH)
25° P.A. GEARS
ADD. - 1/P DED. - 1.35/P FILLET R - .300/P
Y FACTOR
Y
FOR LOAD AT HIGHEST POINT OF SINGLE TOOTH CONTACT - Y'
Y' = Y/0.65
NUMBER OF TEETH

Fig. 7 — Curve for Y or Lewis form factor for standard gear teeth of type used in this transmission.

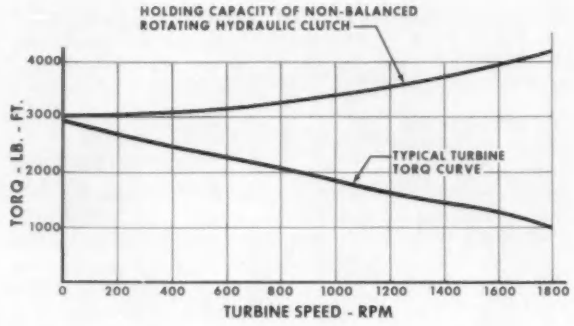


Fig. 8 — Rotating clutch has characteristic exactly opposite to ideal for operation behind torque converter — because of centrifugal effect.

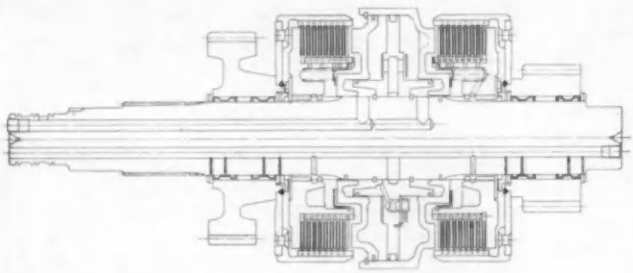


Fig. 9 — Cross-section of duplex clutch used in gearbox.

Twin Disc power shift transmission

. . . continued

has a characteristic exactly opposite the ideal for operation behind a torque converter, as shown in Fig. 8. It is necessary to have sufficient apply pressure to hold stall torque when the clutch is stationary and there is no centrifugal effect. As turbine speed increases, turbine torque decreases, but clutch capacity increases because of the additional centrifugal pressure. One can compensate for this in some transmissions by trimming apply pressure by means of a turbine controlled governor pressure.

The dumped clutch to be applied must be refilled with oil, and this includes the apply passages. How fast the clutch will be applied depends on the piston apply volume, the volume of the apply passages, the pump capacity, regulator pressure, and apply passage restriction. The holding capacity of the clutch is not just a function of the apply pressure but also of the speed at which the clutch is rotating because of centrifugal effect.

Fig. 9, a cross-section of the duplex clutch used in the gearbox, shows how the rotating clutch problems just described are solved. The piston is actually a closed end cylinder sliding over a stationary piston called the clutch carrier. The cylinder is centrally located in the neutral position by means of caged springs in the clutch hubs.

Each side of the cylinder is divided into a large outer volume and small inner volume by a shelf on the carrier. In the center of the carrier is a fifth cavity, which is maintained at a low pressure from the lube system at all times. This same lube supply line in the shaft supplies oil for lubricating the clutch gear bearings and cooling the clutch plates.

The outer volume of each side of the cylinder communicates with this fifth cavity through a series of axial holes. In this way the cylinder is kept filled with oil at all times. It can be seen that centrifugal effects are canceled out by the back-to-back design of the cylinder.

The axial holes are covered by ring valves supported and operated by three small pistons. These ring valves normally permit oil to enter the large volume from the fifth cavity, but do not permit the reverse.

In applying the right-hand clutch, pressure is admitted to the right-hand inner cavity. This pressure is also applied behind the pistons operating the left-hand ring valve, holding it open to permit the exhaust of oil from the left-hand outer cavity into the fifth cavity. Oil from the fifth cavity is drawn into the outer right-hand cavity as this cavity expands, due to movement of the cylinder to the right. It can be seen that the only volume required to fill this clutch is the volume of the inner cavity. Thus, the engagement time of this clutch in an end-to-end shift is 0.3 sec and, in this particular transmission, all shifts are made from the neutral or half-way position, so the shift time is 0.15 sec.

After the cylinder bottoms against the clutch pack and stops moving, the right-hand ring valve closes and the outer right-hand cavity is brought up to apply pressure through the orifices behind the left-hand ring valve pistons. This produces a relatively gradual buildup of holding force and, thus, a smooth controlled shift. The location of the orifices also prevents the buildup of sludge behind the pistons.

Two types of grooving used in the friction plates are shown in Fig. 10. Both are alike in that the grooves are continuous from ID to OD and break up the surface into small pads. The difference reflects the preference of the supplier's from a manufacturing consideration while, from a performance consideration, we lean toward the waffle pattern.

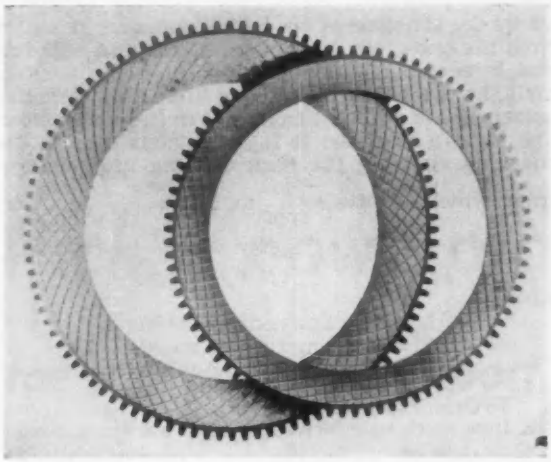


Fig. 10 — Two types of grooving used in friction plates.

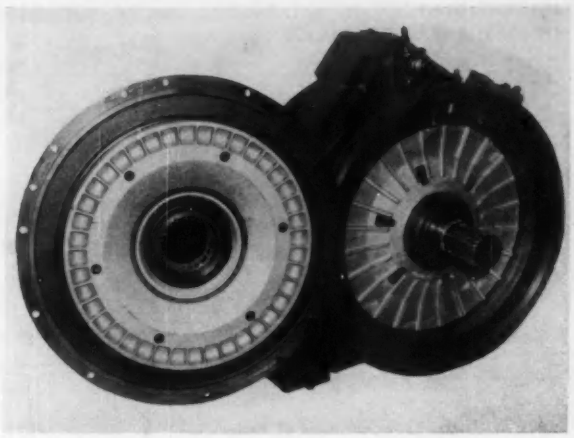


Fig. 11 — Retarder wheel and housing.

When used behind a torque converter on rubber-tired or rail equipment a coefficient of 0.1 is used. On tracked equipment behind a torque converter, a coefficient of 0.07 is used and when used on direct or solid drive systems, the coefficient used is 0.05.

The gross unit pressure on the friction plates is 500 psi. The normal running clearance of the clutch packs is designed to 0.005 in. per friction surface in the minimum dimensional stacked condition.

Hydraulic system

The hydraulic system is similar in most ways to other power shift transmissions except for the hydraulic retarder and the retarder control valving. Fig. 11 shows the retarder wheel and housing.

The stator blading has a semicircular shape somewhat like a half-orange or a typical hydraulic coupling member. The rotor has long and straight radial blades. This configuration is designed to produce the highest braking capacity in a minimum volume for a fast fill time, while also developing a high discharge pressure for circulation of the oil through the heat exchanger.

Fig. 12 is a schematic of the cooler circuit. Note that the large valve for switching the retarder in and out of the cooler circuit is pilot operated. This valve must be large enough to handle the high cooler flows during retarder operation and in the past had been manually operated. The first 0.12 in. of the retarder control valve causes the large valve to switch to the retarder position. Further movement of the valve controls the amount of braking by varying the cooler circuit pressure.

Bearing design

Bearing design is the biggest headache in the design of this type of transmission. In a simple train of gears a desired B-10 life can be attained and then reference can be made to the bearing catalogs for a choice of bearings. But this transmission is to be used in trucks, scrapers, locomotives, front end loaders, and pusher-dozers — each having a different type of operation.

The European method of determining bearing life requirements consists of breaking down the operation of a vehicle very minutely even to time at idle, time at 1/12 power, etc. We choose to simplify this by considering full power operation only, since time at part power has an equivalent value of time at full power in bearing calculations.

The first simplification, then, is to use the full-power condition, the second is to assume the durability base line as 1.25 converter torque ratio and 0.7 speed ratio, as mentioned when discussing gearing. There are some exceptions of course, but this is used for most rubber-tired applications.

Now we come to the real Ouija board section, or "My guess is as good as yours," and that is, how to apportion the desired life between the various gear ratios, since this affects bearing selection. We are working with some customers to obtain information from field installations to do a more intelligent job here. The transmission described here is based on the following schedule of operation in each gear, with the full power B-10 design life set at 4400 hr.

Range	Hr
1	800
2	1400
3	1480
4	600
5	120

This is a "happy medium" schedule for scrapers and trucks.

The B-10 continuous life of each bearing under

Twin Disc power shift transmission

. . . continued

the durability condition for each gear range is then calculated and set up as shown in Table 1.

With the tabulation and the schedule of operation, the weighted life of each bearing can be calculated by means of the formula:

$$\frac{100}{L} = \frac{P_1}{L_1} + \frac{P_2}{L_2} + \frac{P_3}{L_3} \cdots\cdots$$

where:

L = Weighted life, hr

L_1, L_2, etc. = Continuous life in each range

P_1, P_2, etc. = Time in each range, %

The tabulation has another advantage in that if the application engineer has an unusual application where the schedule of operation varies considerably from the one given, he can set up his own schedule and, by means of the chart and the weighting formula, he can check his bearing life. Also, if engine horsepower is different from that in the design baseline, he can alter the B-10 continuous lives in the chart by applying the basic bearing life relationships, which are life $\propto \frac{1}{\text{rpm}}$ and life $\propto \left(\frac{1}{\text{load}}\right)^{3.33}$, or:

$$L_2 = L_1 \left(\frac{N_1 T_1^{3.33}}{N_2 T_2^{3.33}}\right)$$

where:

L_1 = Base line continuous life

N_1 = Base line turbine speed

T_1 = Base line turbine torque

To Order Paper No. 412A . . .
from which material for this article was drawn, see p. 6.

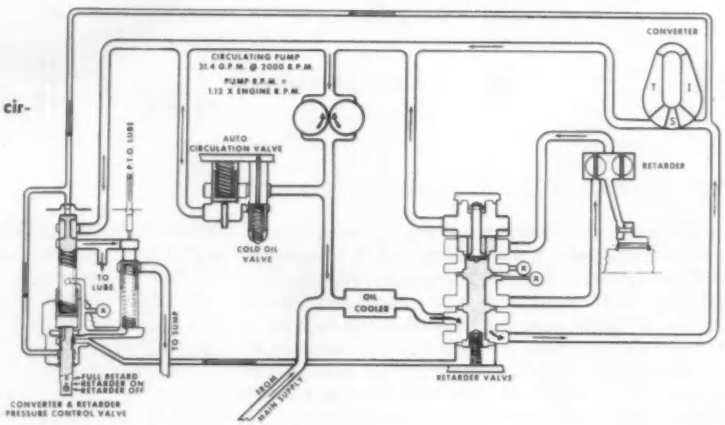


Fig. 12 — Schematic of cooler circuit.

Table 1 — Continuous (B10 hr) Bearing Life for Model TA-51-2001 Transmission

(Design point: 1330-ft-lb input torque; 1400-rpm input speed)

No.	Size & Type	Shaft & Location	B10 Life, hr					
			In First Gear	In Second Gear	In Third Gear	In Fourth Gear	In Fifth Gear	In Reverse Gear
1	5214 roller	Main input-front	13,600	16,300	810,000	16,300	810,000	13,600
2	1214 roller	Main input-rear	3,540	164,000	4,860	1,860	5,700	
3	1215 ball	1-R input-front	1,500					1,500
4	1215 roller	1-R input-rear	10,650					645
5	1214 roller	2-4 input-front		2,230		2,230		
6	1214 roller	2-4 input-rear		138,000		1,990		
7	3214 ball	3-5 input-front			43,500		43,500	
8	1214 roller	3-5 input-rear			4,360		4,360	
9	5214 roller	1-R clutch-rear	755					
10	5212 roller	2-4 clutch-rear		1,360				
11	5212 roller	3-5 clutch-rear			2,870			
12	TDO 495 taper	Output-rear	2,220	12,900	30,200			
13	HJ-283720 needle	Output-front	4,610	67,000	289,000	1,700	1,330	
14	1312 roller	Reverse-front						260
15	1312 roller	Reverse-rear						158

Pick a powerplant

for a Mach 3 transport

Some important considerations

are discussed in this article.

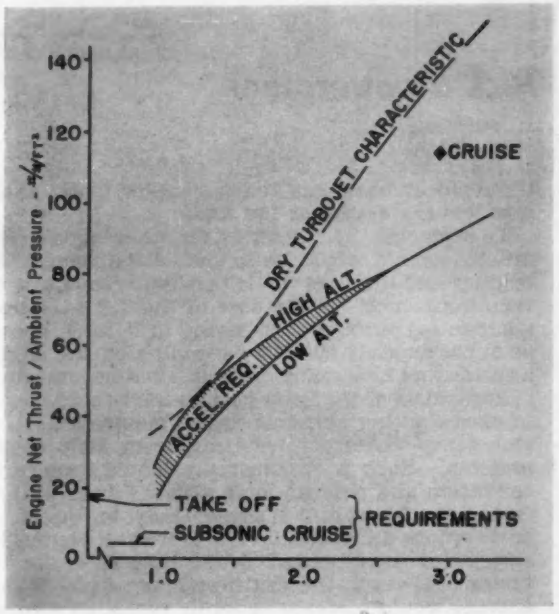


Fig. 1—Typical powerplant thrust requirements for a Mach 3.0 transport. Also shown is the thrust characteristic of a dry turbojet sized for altitude acceleration.

Based on paper by

R. C. Hawkins

General Electric Co.

THREE BASIC considerations involved in choosing a powerplant for a Mach 3.0 commercial transport are:

1. Thrust flexibility in meeting aircraft requirements between take-off, climb and acceleration, and subsonic and supersonic cruise.
2. Special performance considerations, such as inlet compatibility and engine component efficiencies.
3. Life and reliability in the severe operating environment at Mach 3.0.

Thrust flexibility

The aircraft is required to accelerate through the subsonic speeds into the transonic region, and upward to cruise speed. Of course, the engines cannot operate at minimum specific fuel consumption throughout this flight spectrum. Where they cannot, the engines are said to be mismatched. This is a serious problem when the region of mismatch occupies a prominent range in the spectrum, in which the airplane might be expected to linger as a matter of course or for some type of emergency. Mismatch may even be as important as basic engine cycle in determining the resulting cruise fuel consumption. It also gives some insight into the controversial argument as to the relative cruise sfc advantage of various engine types.

The acceleration requirement can oversize an engine to such an extent that a mismatch would occur at the Mach 3 condition. Fig. 1 indicates how extreme the thrust mismatching problem may become. The curves give a generalization of engine thrust requirements over the flight spectrum, and the thrust characteristics of a typical non-augmented turbojet, sized for altitude acceleration. Evidently, this engine is mismatched for all other major operating areas. This is significant since the dry turbojet is the least complex of all probable engine types.

Mach 3.0 cruise sfc will be an important economic aspect of the commercial transport, but it could be offset by differences in subsonic engine performance. This is certainly true at the present stage of configuration development since variations in cruise sfc are not large enough to be the deciding factor. In addition to the potential transonic-supersonic cruise matching problem, a potentially serious transonic-subsonic mismatch will be present regardless of the acceleration altitude. The importance of loiter or subsonic diversion to an alternate destination is still not clear; the requirement itself may not even arise. Assuming, however, that it will exist, the engine will have to be very flexible to provide an attractive loiter sfc at 5000 ft and still be capable of other Mach 3.0 requirements.

The fan engine is desirable in this respect because it has a size and cycle advantage, particularly for low altitude operation. As opposed to the acceleration and supersonic flight regimes where fan-engine augmented thrust is a function of total airflow, the subsonic non-augmented thrust is essentially de-

Pick a powerplant

... continued

termined by basic gas generator flow (total engine flow less the bypass or fan flow).

To overcome the size effect for other engine types, an obvious aid would be to shut down some of the engines and increase the thrust requirement on the remaining ones. In the case of the T.P.A. (tailpipe augmenter) turbojet, the saving in loiter fuel could be approximately 20–40% depending on the holding altitude and how many engines could be shut down.

Regardless of the loiter requirement there appears to exist another subsonic cruise requirement — the emergency condition resulting from slow decompression. Such a circumstance would require deceleration and descent to an altitude close to 15,000 ft, and continued cruise, subsonically, to the original or alternate destination. For overwater routes, this emergency requirement could become a limiting factor. However, the shutting down of one or more engines would increase subsonic range, particularly for a turbojet-powered aircraft.

Power loadings will most likely be high enough so that take-off thrust may not be limiting. But engine specific thrust and the resultant community noise level may dictate one engine parameter — a minimum total airflow. This factor will probably vary from 400–500 lb/sec, depending on engine type (specific thrust), and will be significant in some cases

Airflow or engine size, is largely determined by specific thrust in the transonic area. The airflow requirement will probably not be drastically changed by variations in aircraft configuration, with the possible exception of variable sweep. Relative specific thrust (lb thrust/lb air) is shown in Fig. 2. Also shown is the specific thrust limit as it appears to be established by airport community noise level. Apparently, the full reheat turbojet is eliminated and a modest augmentation ratio is suggested. Such a T.P.A. turbojet would be heavier but simpler than a full reheat turbojet having equal thrust.

Relative engine weights are best compared by the specific weight (lb/lb thrust) as in Fig. 3. From this standpoint the full reheat fan engine is again attractive since it would have a high airflow capacity combined with low engine weight.

Special performance considerations

Inlet-engine compatibility is one requirement that will be critical to the configuration selection. It will determine what the engine installation will be — podded or buried. Fig. 4 shows corrected airflow capacities versus cruise Mach number of the two types of inlet for reasonable inlet configurations. For a three dimensional translating spike configuration (podded), a Mach 3.0-to-transonic corrected-airflow ratio well below .6 would require a very long inlet with large spike translation. There would be an undesirable weight penalty in this case. Conversely, a buried installation with a collapsible ramp inlet has a cruise-to-transonic airflow ratio capacity under .5.

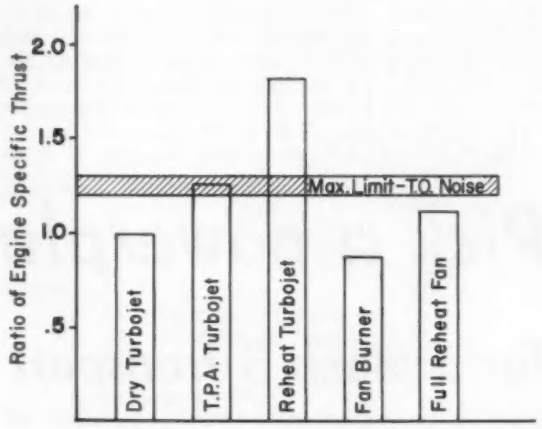


Fig. 2—Relative engine specific thrust at the transonic acceleration point, and the limit set by take-off noise.

Applying these requirements to two probable engine types, the fan and turbojet, gives some interesting relationships. Since thrust requirements are approximately the same for both engine types, and Mach 3.0 cruise specific thrusts are equivalent, both would be expected to use about the same Mach 3.0 cruise airflow. The turbojet would operate at maximum airflow capacity and the fan at part capacity. The fan engine, in a buried installation, would operate with approximately the same airflow as would the turbojet in either installation. However, for a pod installation, the fan engine could operate at more nearly its normal airflow capacity and with low fan stream augmentation to achieve a desirable airflow and thrust match. This would not represent a cruise performance penalty.

The fan engine has airflow and thrust characteristics better suited to buried installations than does the turbojet. But a clear-cut engine preference for the podded installation must await further analysis.

For non-standard day operation, present transport proposals include variation of cruise Mach number to obtain constant engine inlet temperature. This would involve additional inlet-engine matching requirements. An inlet designed for standard day Mach 3.0 cruise would normally require a 10–12% spill requirement at hot day cruise (approximately Mach 2.8). To avoid this mismatch, the inlet may be designed for the oblique shock to lip intercept to occur at hot day cruise. Then engine airflow would have to be controlled as a function of cruise Mach number. Since the turbojet engine would not normally have the required hot day cruise airflow capacity, they would have an additional design requirement involving increased weight, size and/or turbine inlet temperature.

Inlet-engine matching must also take into account system tolerances and their effect on requirements. Actual inlet and engine flow values will vary from design values due to production differences, control tolerances, component performance deterioration and flow deterioration from foreign object damage.

Fig. 3—Relative engine weight based on equal acceleration thrust.

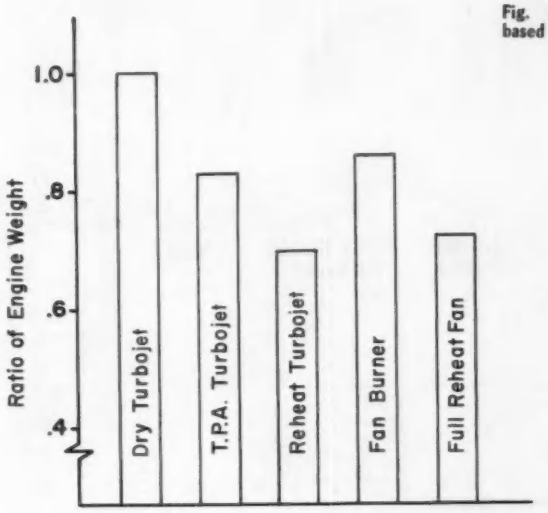
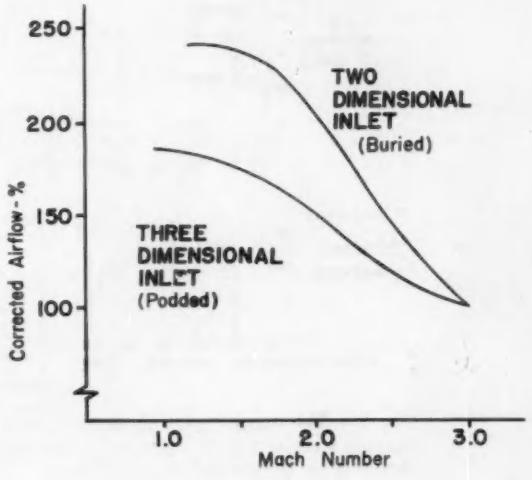


Fig. 4—Inlet corrected airflow characteristics.



Using separate inlet-engine control systems would make cruise ram recovery within 2–2½% of peak value difficult to obtain. Auxiliary bypass equipment used to compensate for transient airflow inconsistencies would operate almost continuously with the associated performance penalties.

Maximum system performance may well be obtained by an integrated inlet-engine control system, with final Mach 3.0 engine flow adjustments being determined by the inlet throat normal shock position. Bypass equipment would be used to handle transients since engine response rate appears unacceptably slow.

Life and reliability

The Mach 3.0 environment is both different and more demanding than that associated with subsonic transports. The high ram temperature rise at the Mach 3.0 cruise decreases its potential for use as a cooling agent, as well as changing component design criteria. Compressor inlet temperatures of approximately 700 F at Mach 3.0 contrast with temperatures of 0 to 100 F for the subsonic case.

At Mach 2.0, engine oil can be cooled in an air to oil heat exchanger, and hydraulic oil can likewise be cooled up to approximately Mach 2.4. At Mach 3.0, though, engine fuel is the only heat sink still available for practical use. But it is no longer the low temperature, almost infinite heat sink that is in today's subsonic transports, since it has been preheated in its cells or compartments. It is estimated that the temperature of the fuel going into the cold side of the engine heat exchanger will be higher than the heat exchanger oil-out temperature of most current engines. An exacting analysis of heat loads and thermal gradients is essential if desired commercial life is to be retained.

Due to the high ambient temperature surrounding the engine at cruise, the once tolerable liquid leaks foward of the engine firewall now represent a fire hazard. Consequently, it is mandatory to eliminate as many joints as possible, possibly use shielding and insulation, and take advantage of modular design with fire inerting or quenching features.

Engine performance at Mach 3.0 cruise calls for relatively high turbine inlet temperatures. This combined with the high compressor inlet and discharge temperatures means that 50 to 75% of the engine components will be life-limited at the cruise conditions. This figure is about 10% for subsonic engines. Successful design will hinge on a thorough understanding of material properties in the creep and stress rupture range.

An extension of present reliability concepts will have to be incorporated in the engine development program. Design specifications shall include reliability requirements and component development programs must show probability of achieving these objectives before engine development proceeds.

To Order Paper No. 427B . . .
from which material for this article was drawn, see p. 6.

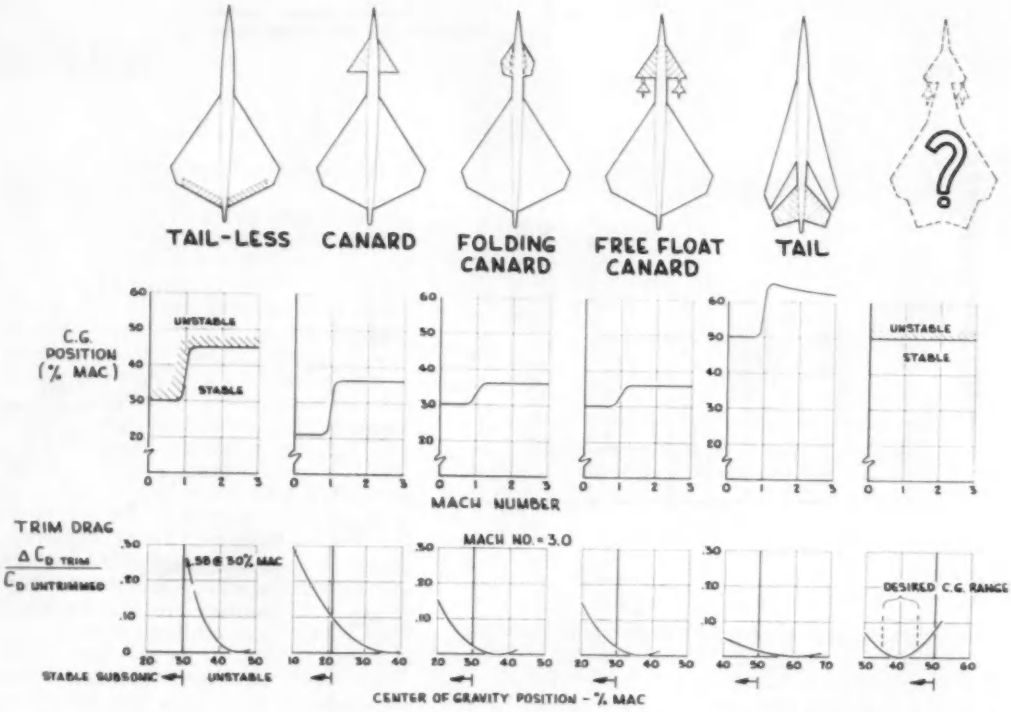


Fig. 1— **The upper curves show** the center of gravity position requirements to achieve stability for the various configurations illustrated. The lower curves show how much drag is involved in trimming each airplane for subsonic static stability.

Trim drag helps mold

One of many factors

Based on paper by

R. B. Brown

The Boeing Co.

THE TRADE between subsonic stability and supersonic trim drag is one of the fundamental design considerations in a supersonic cruise airplane, and poses a very serious problem. All supersonic airplanes have additional drag associated with trimming out unbalanced moments. Minimizing this drag through different configuration approaches is possible.

There is one setting of the control surfaces of any supersonic airplane configuration where minimum drag is achieved. Any other setting will result in an increase in drag; defined here as trim drag. Fig. 1 shows how trim drag varies for different airplane configurations.

The upper row of curves gives center of gravity position limitations required for stability through the plane's speed range. For example, the tail-less version has a c.g. limit of 45% of the mean aerodynamic chord at a speed of mach = 3, and a limit of 30% MAC for subsonic flight. The price that must be paid to attain subsonic stability is indicated in the lower row of curves. Here, the trim drag is plotted as a fraction of the total untrimmed airplane drag. The drag varies as a function of the c.g. position since this establishes the trim surface angle. Evidently, the trim drag of the tail-less airplane in subsonic flight is 0.58 × Untrimmed Drag. The values shown in the curves apply only for the geometries and surface controls shown. They do not include the effect of wing twist or larger control surfaces which will reduce the trim drag, especially for the tail-less airplane. But the values shown do correctly represent the seriousness of the situation.

Two other means besides trim surface deflection could be used to stabilize the tail-less airplane in subsonic flight, but both are not feasible. One possibility is to shift a major portion of fuel aft for su-

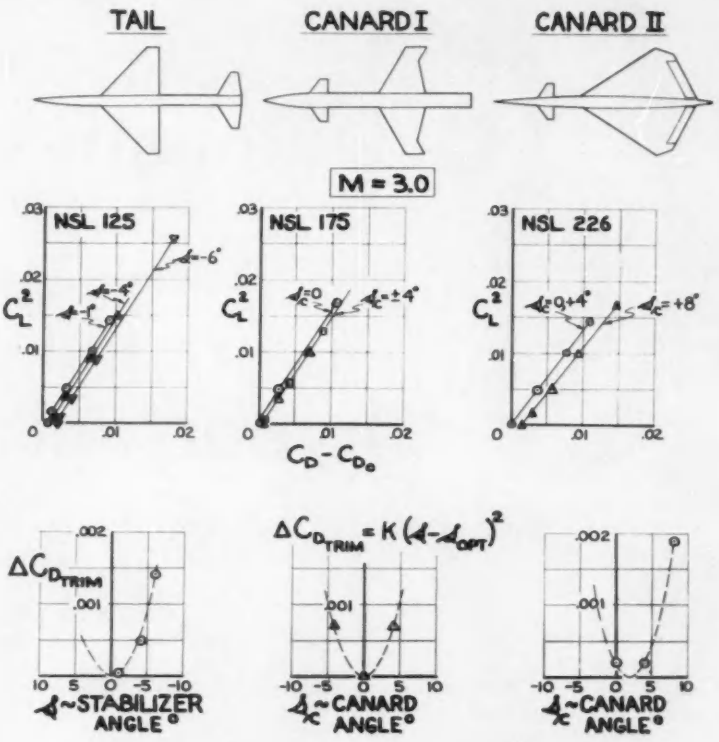


Fig. 2 — **These data were obtained** from wind tunnel tests at M = 3.0 with the configurations that are illustrated. The upper curves show that the minimum drag setting and the incremental drag due to settings other than optimum are independent of lift coefficient. The lower curves demonstrate that incremental drag varies as the square of trim surface deviations from the optimum setting.

supersonic transport's shape

affecting configuration choice.

personic flight and forward for subsonic flight. This would permit positive static stability at all times. However, this is unacceptable for transport operation because fuel system operation is now dependent upon both gross weight and flight speed. The other possibility is to position the c.g. aft for all flight speeds. The static instability that would result in subsonic flight could be overcome with augmentation devices. Unfortunately, the reliability history of such devices is not sufficient to permit this solution for supersonic transports.

The canard airplane has moderate values of trim drag when operated with the center of gravity at the subsonic neutral point. Flight at the neutral point is probably a limiting condition and much of the operation would be at positive subsonic stability margins. The trim drag with normal stability margins is unacceptable.

The folding canard configuration has the canard hinged at the side of the body and positioned vertically for subsonic flight. In supersonic flight it is folded to a horizontal position. This reduces the

Table 1 — Nomenclature

C_D	— Drag coefficient.
s	— Trim surface angle relative to configuration reference plane.
s_{opt}	— Trim surface angle for minimum total configuration drag.
$C_{M_{s=o}}$	— Moment coefficient at zero total configuration lift for zero trim surface angle.
C_L	— Total configuration lift coefficient.
$\frac{dC_M}{dC_L}$	— Stability margin, fraction MAC.
$\frac{dC_M}{ds}$	— Trim surface effectiveness per unit of deflection.

Trim drag helps mold supersonic transport's shape

. . . continued

center of pressure shift. When flown at the subsonic neutral point the trim drag is very small. Another variable geometry approach which gives similar trim drag characteristics is the use of folding wing tips. These variable gecmetry devices are relatively low risk and may be acceptable for transport operation.

The aerodynamically controlled free-float canard configuration has the canard on a transverse hinge through the fuselage with complete freedom in pitch. An aerodynamic tab positions the canard. The concept is similar to a tab-operated elevator on a conventional airplane. The effective center of pressure shift is reduced, and the trim drag when flown at the subsonic neutral point is very small. Considerably more development effort than the folding canard or folding wing tips is required to establish a reliability level acceptable for transport operation.

The large control surface size and tail arm of the tail airplane gives low values of trim drag when flown with the c.g. positions giving positive subsonic stability.

The last column of Fig. 1 shows the desired trim drag relationships. It is possible to achieve these characteristics with several combinations of the trimming techniques shown. However, supersonic drag is only one of many factors to affect the choice of configuration and will be compromised on any airplane produced.

Trim drag equations

The wind tunnel drag characteristics of three different configurations tested at M = 3.0 in the MIT supersonic wind tunnel are shown in Fig. 2. It is found that the minium drag setting of the trim surface is independent of lift coefficient in all cases. This is also true of the incremental drag due to trim surface settings other than that for minimum drag. Incremental drag varied as the square of the trim surface deviation from this optimum setting. The characteristics are true for all types of configurations over the range of lift coefficients of interest. This permits a very simple solution for trim drag as follows:

$$\Delta C_{D_{\text{trim}}} = \frac{dC_D}{d(S)^2}\,(S - S_{\text{opt}})^2$$

$$\Delta C_{D_{\text{trim}}} = \frac{dC_D}{d(S)^2}\,\frac{\left(C_{M_{\alpha_B=0}} + \dfrac{dC_M}{dC_L}\,(C_L) - S_{\text{opt}}\right)^2}{dC_M/ds}$$

The nomenclature is given in Table 1.

The coefficients for the above equations should desirably be obtained from wind tunnel data. However, analytical methods will give satisfactory results for the more simple configurations.

To Order Paper No. 423D . . . from which material for this article was drawn, see p. 6.

Detonative brightens hypersonic

Based on paper by

M. Arens

Technion-Israel Institute of Technology

CONVENTIONAL ramjets designed for hypersonic flight encounter many problems which could be alleviated by using detonative combustion. With normal combustion, flame propagation velocities of hydrocarbon-air mixtures are relatively low. Consequently, current combustion chamber designs must use low subsonic inlet Mach numbers. But with detonative combustion, flame speeds are high (several orders of magnitude higher than the ordinary velocity of propagation), and inlet velocities can be correspondingly high.

This means that combustible mixtures can be burned at supersonic speeds in a ramjet combustion chamber instead of first having to be diffused to subsonic speed. Without the need to slow down the air, the following improvements result:

- There is no longer a need for the heavy, complex inlet to diffuse the air from the flight Mach number to a low subsonic Mach number. Such inlets have poor efficiency. By carrying out the combustion process at supersonic flow velocities, little or no diffusion is required at the inlet.
- The exhaust nozzle can do without a convergent section. In conventional ramjets, efficient nozzle operation calls for a large exit to throat area ratio since pressure ratios above 100 are available at hypersonic speeds. These nozzles would be long and relatively heavy.
- The lower temperatures and pressures that would exist in the engine means that less heat would be transferred to engine parts. With diffusion, engine components would operate at extreme temperatures and they would all require cooling, including the inlet.
- Efficiency would be higher. The high temperature of the incoming air stream when deceler-

combustion

outlook for

ramjet

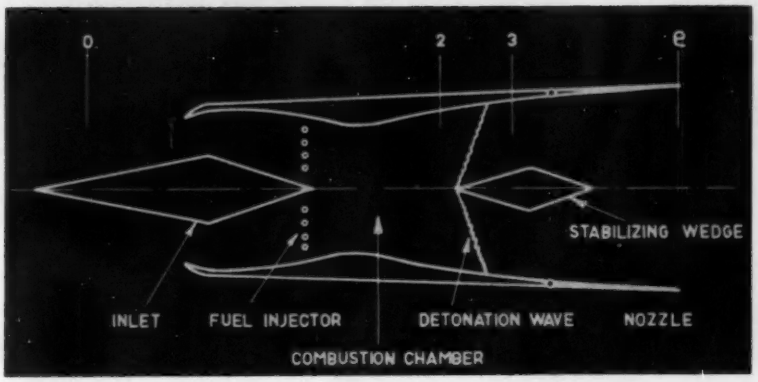


Fig. 1 — **Hypersonic ramjet configuration** for using detonative combustion. It can also be used with conventional subsonic combustion chamber performance by forming a throat in the nozzle.

ated to subsonic velocities reduces the efficiency of the combustion process. With increasing speed a progressively higher fraction of the energy liberated in combustion is absorbed in dissociation and ionization reactions. It then becomes unavailable for raising the kinetic energy of the exhaust gas molecules. At speeds beyond Mach 5 the efficiency of conventional ramjets can be expected to decrease.

Wave stabilization

Detonation waves moving into stationary gas mixtures were observed over fifty years ago, but only recently have standing detonation waves in moving gas mixtures been produced in the laboratory. It is this achievement that raises the possibility of utilizing stabilized detonation waves to burn combustible mixtures at supersonic speeds in a ramjet combustion chamber.

Detonation waves, like shock waves, apparently may be stabilized normal to the stream velocity in diverging passages, or at an angle to the stream velocity on wedges or cones. Experiments have only succeeded in identifying detonation waves which move with sonic velocity relative to the burned gas. A standing wave of this type is characterized by supersonic gas velocities entering the wave, and a sonic velocity component normal to the wave surface leaving the wave. The entering velocity component normal to the wave surface must be equal to detonation velocity of the fuel-air mixture for the wave to be stabilized at a particular location in the combustion chamber. This requirement is analogous to the condition required to stabilize shock waves in supersonic passages.

To stabilize the wave in a diverging passage the stream velocity must reach the detonation velocity somewhere along the passage. A stabilized wave at an angle to the stream velocity requires that the velocity normal to the oblique detonation wave must equal the detonation velocity. In either case, the wave can be allowed to find its equilibrium position.

A typical engine layout is shown in Fig. 1. This configuration permits either a normal detonation wave stabilized in the diverging chamber passage, or an oblique wave stabilized on the wedge. The mean flow in the engine is supersonic throughout, except for the sonic condition behind the normal detonation wave. The same engine can be operated with conventional subsonic combustor performance by forming a throat in the nozzle, thus forcing a normal shock into the inlet.

The maximum allowable detonation velocity depends on flight Mach number and altitude. Since the detonation velocities of fuel-air mixtures generally exceed 4500 ft/sec, detonative combustion can be maintained only at hypersonic flight speeds. As a rough guide, detonative combustion is feasible when the flight velocity exceeds the detonation velocity.

Performance

In the case where a perfect inlet is assumed, calculations show that the optimum specific fuel consumption is obtained when conditions are very close to those required for normal detonation, or maximum diffusion. For lower inlet efficiencies, operation with oblique detonation wave stabilization is preferred over normal detonation. Particularly at higher speeds, optimum performance is obtained with relatively little inlet diffusion. The ratio of flight speed to specific fuel consumption, an index of engine efficiency, continues to increase with flight Mach number, and compares favorably with the performance of conventional ramjets at speeds between Mach 3 and 4.

To Order Paper No. 419A . . .
from which material for this article was drawn, see p. 6.

The Breguet 941

One Engine Out— But All Props Turn

New Breguet 941 STOL aircraft, flown for the first time at the recent Paris Air Show, employs an unconventional propeller system for better control and safety.

Based on paper by

Georges Ricard, Joseph Czinczenheim, P. E. Jaillard and Guy de Richemont

Societe des Avions Louis Breguet

THE only unconventional feature of the Breguet STOL aircraft, but a vital one, is its propeller system. More precisely, the innovation consists of the pitch control mechanism and the interconnecting shaft.

The propeller system, shown in Fig. 1, is driven by four free turbine turbo-prop engines. Each driven turbine is mechanically connected to a first stage reduction gear, near the propellers, where the rpm is reduced to the desired value.

All four propeller shafts are mechanically interconnected by a transmission shaft which incorporates several safety features. For example, should any engine fail it would be isolated by a free wheel on its longitudinal connecting shaft. The propeller would still be driven by the shaft, though, receiving its power from the three remaining engines. A failed propeller can be isolated from the system with a mechanical clutch provided on the propeller shaft. De-clutching also actuates the propeller feathering system while the three remaining propellers are driven by the four engines. In the case of seizure of a gearbox, the lateral connecting shaft near each angular gearbox has a shear neck which will break.

The connecting shaft ensures that all the propellers have the same rpm, but the pitch control is required to properly operate the pitch settings. The pitch control is operated by a central mixing box. Signals received by the central box are transmitted by a torsion shaft to the four propellers. The signals are derived from an rpm central regulator driven by the transmission shaft and:

- In STOL condition — from the position of the stick in lateral control.
- In transparency (zero equivalent pitch) — from an actuator directly controlled by the pilot.
- In reversal — under pilot's control.

Basically, the interconnecting shaft is provided to overcome the dissymmetry resulting from a single engine failure. If an engine fails at take-off, the aircraft remains symetrical; there is no speed limitation by the minimum speed of control. Even though 25% of the power is lost, the drop of the

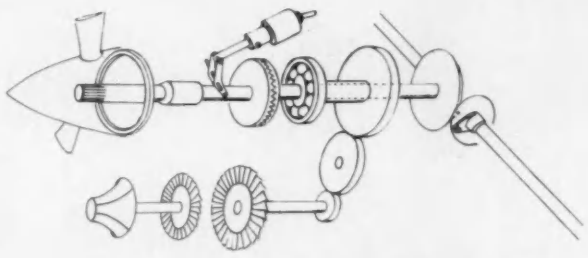
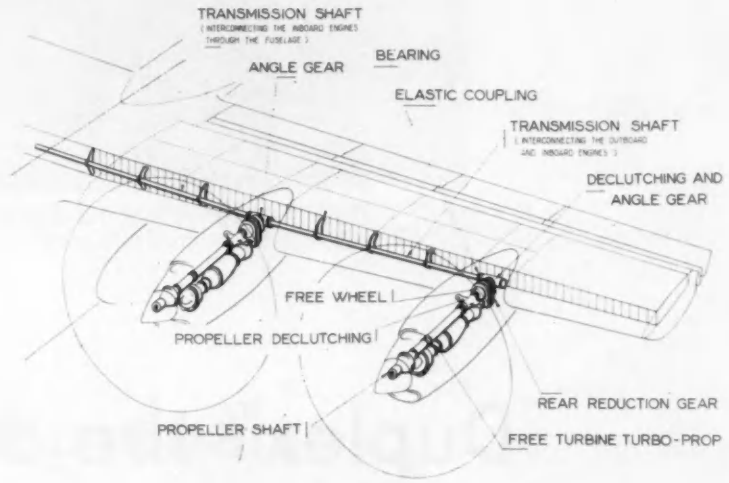


Fig. 1 — Propeller system of Breguet STOL. Some of the transmission safety devices are shown in the detail sketch.



power loading improves the propeller thrust efficiency. This is especially important for the STOL aircraft which depends, in part, on lift supplied by the propeller.

The major difficulty in STOL is not take-off, however, but landing. If very short landing distances are to be achieved, a very steep angle of descent is required. This is not easy to do when a lot of power is used to induce lift. Compensation must be made for the unwanted thrust of the propellers. The solution adopted with this airplane is to use the existing shafting to transfer the power of all four engines onto the inner propellers; while the outer propellers are set at zero equivalent pitch. A tremendous induced drag is built up by the wing which has an equivalent aspect ratio much smaller than its geometry indicates. This, combined with the heavy drag provided by large flap deflections, has made it possible to achieve in-flight approach slopes of 20%.

In case a go-around were required on landing the procedure is fast and safe. As soon as the pitches of all four propellers are re-equalized, the additional induced drag disappears, and the aircraft can climb again. Power buildup time of the engine is not involved; only the rotation of the blades and the aerodynamic time lag.

On the Breguet STOL, just at the begining of the flare, all four propellers are reversed in the following sequence: first the outer propellers go into negative pitch, followed by the inner propellers. At no time are all four propellers at zero pitch, so the propeller system has no tendency to overspeed, even though the power setting has been maintained on the engines. The effect of this reversal is to destroy the induced lift by cutting off the propeller slipstream. The resulting increased weight on the wheels aids the braking action. In addition the negative thrust aerodynamically slows down the aircraft.

The propeller system also help to maintain lateral control. Tests made in the STOL condition demonstrated that lateral control with ailerons alone was inadequate. The rolling moment due to the ailerons was almost negligible, while the adverse yawing moment was impressive. Aileron motion induced almost no roll but did produce heavy sideslip. To remedy the situation, the pitch of the outer propellers is governed by the lateral control in the STOL configuration. The pitch of the propeller outside of the turn is increased; which increases the induced lift corresponding to a direct roll, and increases the propeller thrust corresponding to a direct yaw. Differentially, the pitch of the propeller inside of the turn is decreased, inducing additional yaw in the same way. The transmission shaft serves to transmit power from one propeller to the other as required. Trailing edge spoilers have also been added for further improvement.

To Order Paper No. 428A . . .
from which material for this article was drawn, see p. 6.

Fig. 1 — **Duplex tire (right) is slightly larger** in diameter than duals but single tire results in substantial weight savings.

"Duplex" tire designed

Based on paper by

Ray Kupp and E. B. (Bert) Ogden

Consolidated Freightways, Inc.

THE "DUPLEX" TIRE is a single tire capable of carrying the load of duals, yet little larger in diameter. The new tire saves weight, approaches duals in mileage, and makes possible better design of vehicles.

DUPLEX SAVES WEIGHT

Fig. 1 compares the single Duplex tire with 1100 × 22.5 duals. The diameter of the single tire is slightly larger, but midway between the 1100 × 22.5 tire and the next larger size. Note that there is a weight saving of about 150 lb per hub. On a three-axle tractor this can be multiplied approximately by four for a 600 lb weight saving, to say nothing of the saving on the trailer.

APPROACHES DUALS IN MILEAGE

Fig. 2 shows a set of Duplex tires run on our equipment. The two tires on the left went a distance of 54,000 miles at 55–60 psi inflation on 16,000 lb gross axle loadings. No flats were encountered and the mileage approaches that of conventional duals. The next set of Duplexes we plan to run will come from a production mold with increased tread. We are confident that the mileage challenge can be met.

BETTER VEHICLE DESIGN POSSIBLE

Fig. 3 shows the Duplex mounted on the left rear of a truck with a set of duals on the right. Note the differences in clearance between the tires and the springs. It is intriguing to visualize changes in vehicle design to stabilize the upward height trend of vans by widening the load bearing on the axles. Also, cooler drum operation with resulting savings in drums and linings are possible since the brake drum can actually be moved out into the air stream.

GREATER ROAD CONTACT

A set of Duplex tires with 70 psi tire inflation and 18,000 lb per axle load has 266 sq in. of road contact per axle. A set of dual tires on the same axle, inflated to 75 psi (which would be the running pressure required to carry the 18,000 lb) has a road contact of 62 sq in. per tire or a total of 248 sq in. on the highway. Thus there is an advantage of 18 sq in. of road contact with the single tires. Also, there is no possibility with the single tire of transferring the load to less road bearing area as is possible with the duals.

To Order Paper No. 415B . . .
from which material for this article was drawn, see p. 6.

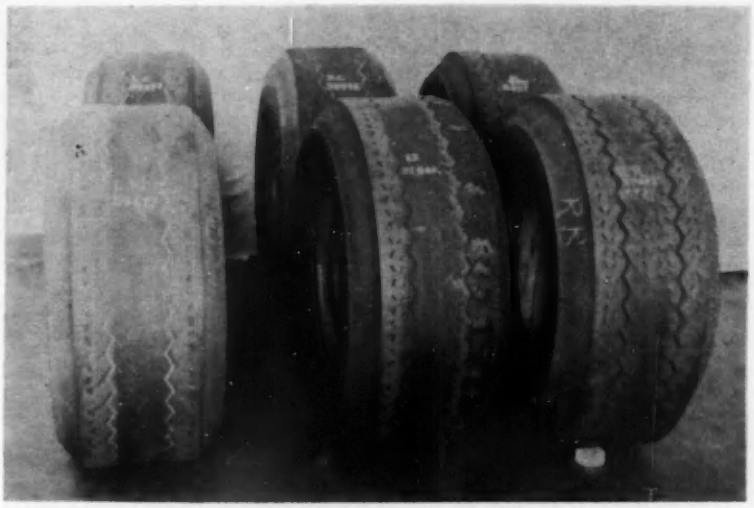


Fig. 2 — **54,000 miles of service without a flat** were experienced by the two tires at the left (front and rear) in this set of Duplex tires. Mileage is approaching that of duals.

to replace duals

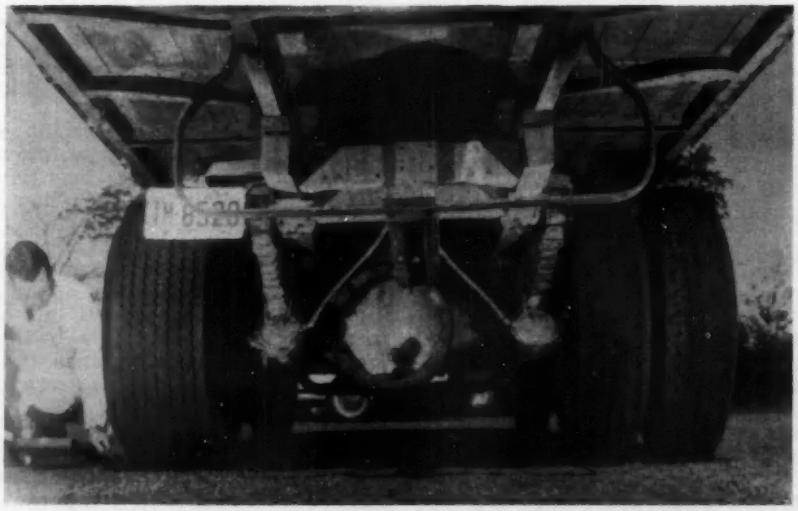


Fig. 3 — **Greater clearance between tire and springs** results wth Duplex tire (left). This opens opportunities for better vehicle design.

2 new fuel controls for industrial gas turbines

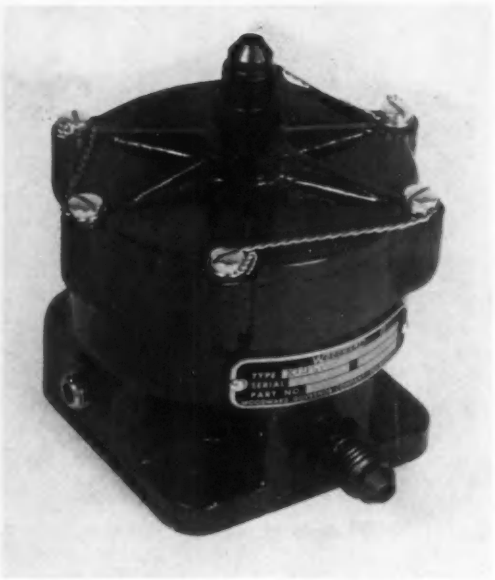


Fig. 1 — Type 1945 fuel control unit is about 3 in. high and 3 in. in diameter. It is designed for mounting either on top of pump or independently.

- *Simple, single-fixed-speed units designed for low compression ratio engines.*
- *Variable-speed unit designed for high compression ratio engines.*

Based on paper by

F. W. Newburgh and Bruce Ingold

Woodward Governor Co.

THE type of fuel control needed on a gas turbine depends on the particular gas turbine it is to be applied to. For instance, a low compression ratio gas turbine that is to be used at a single fixed speed can use a simpler, less costly fuel control than can a variable-speed turbine operating at high compression ratio.

Both these types will be discussed here.

Simple unit for low compression ratio turbines

At present under test, for example, is the type 1945 (Fig. 1) — a simple fuel control unit for low compression ratio gas turbines. It will produce an acceleration fuel flow as shown by Fig. 2 and will control steady-state fuel. It contains five moving parts, as shown in Fig. 3.

Fuel flows into the control through port A. The bypass valve B maintains an essentially constant pressure drop from the inlet to port C, the discharge to the engine nozzle. A relief valve, as shown, protects the fuel pump from excessive pressure. Restrictions are added between port A and port C, so that the bypass valve will open, more fuel will be bypassed back to the pump, and less will be sent on to the engine. One restriction is at D, which is varied in size by needle E, which in turn, is moved by governor weight F.

To govern, the governor weight moves out, needle E partially restricts the flow through D, the pressure drop increases, and bypass valve B returns more fuel to the pump. Another restriction is in series with D at G. This hole is varied in size by speed weight H working against leaf spring I. At low engine speed, needle J restricts the flow to the engine to starting fuel levels. As speed increases, the needle gradually moves out of restriction G, permitting more fuel to flow to the engine. When the requested speed is reached, the speed governor weight moves needle E into restriction D, thereby further reducing engine fuel flow to maintain governed speed.

When small load changes tend to change engine speed, the governor weight will move needle E in and out of the restriction to permit a little more or a little less fuel to flow to the engine combustion chamber to produce the heat energy necessary to

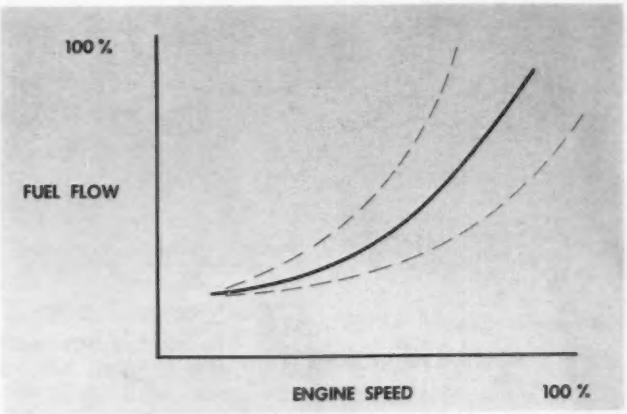


Fig. 2 — Typical type 1945 acceleration fuel flow schedule.

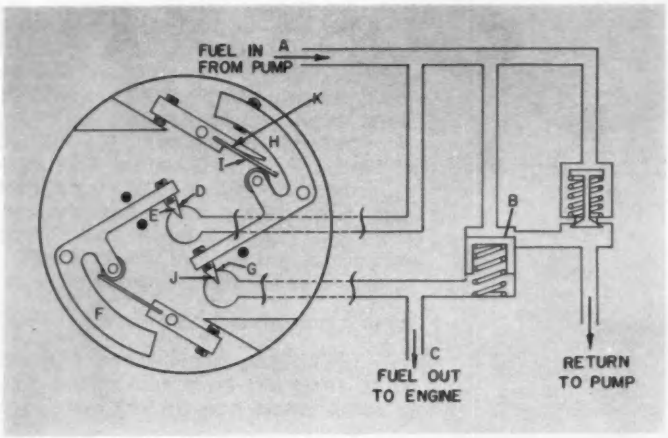


Fig. 3 — Type 1945 fuel control unit contains five moving parts.

maintain the requested speed. Should a large decrease in load occur, the governor weight will sense the resultant increase in engine speed, and will close the restriction until the energy of the fuel supplied just matches the energy needed to maintain the engine on speed at the new load.

To provide a sufficient spring load with spring I for the centrifugal force of weight H to work against over the wide speed range without resorting to the usual valve-servo-feedback arrangement or parabolic spring design, a relatively simple cam device, as shown at K, was employed. With this, the effective spring scale is changed as a function of flyweight position. The position of needle J, therefore, can be made linear with speed. Fuel flow to accelerate the engine is preset by selecting the proper contour of needle J.

Maximum horsepower limiting is accomplished by the screw adjustment, which limits travel in flyweight H, and thereby flow. Minimum flow is set by positioning needle J with flyweight H against its low-speed stop.

To allow accurate positioning of the needles in their respective orifices, the flyweights are suspended horizontally on cone points to reduce friction. This feature also eliminates bearing costs without sacrifice of accuracy.

Control for high compression ratio turbines

Also under test is the type 1910 — a self-contained oil-lubricated computer section with an output shaft that can be used to position either a liquid or gaseous fuel metering valve.

The computer package (Fig. 4) has been designed for use with adapters for mounting the control to various engines. The adapters (Fig. 5) contain special equipment for use on only one engine.

A block diagram (Fig. 6) of the 1910 shows an all-speed governor that is limited by a lever that is positioned by engine compressor discharge pressure, engine rpm, and compressor inlet temperature. The output of the combination moves a fuel valve to regulate the amount of fuel that is sent to the engine. A simple schematic (Fig. 7) shows the throttle, which positions a spring that applies a force against a set of flyweights. When the engine speed causes the weight force to overcome the spring force, the output rod will move to reduce fuel to the engine. Should the operator ask for more power by moving the throttle to increase the spring force, the flyweight force will be overcome, and the output rod will move to increase fuel flow. On a large load demand, it is quite possible that the output rod would move in the open direction until it hit against the adjustable movable stops in the limiting lever. Then the maximum allowable fuel valve opening is determined by compressor discharge pressure, compressor inlet temperature, and engine speed output linkages. Should compressor discharge pressure increase, as during an accelera-

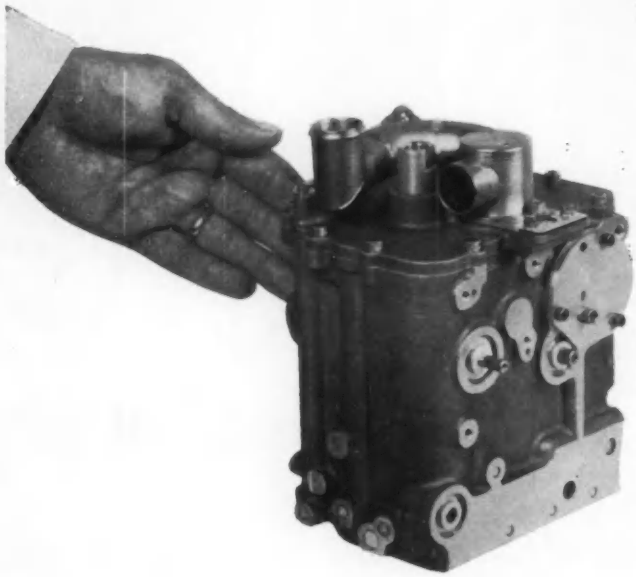


Fig. 4 — Computer section of type 1910 unit.

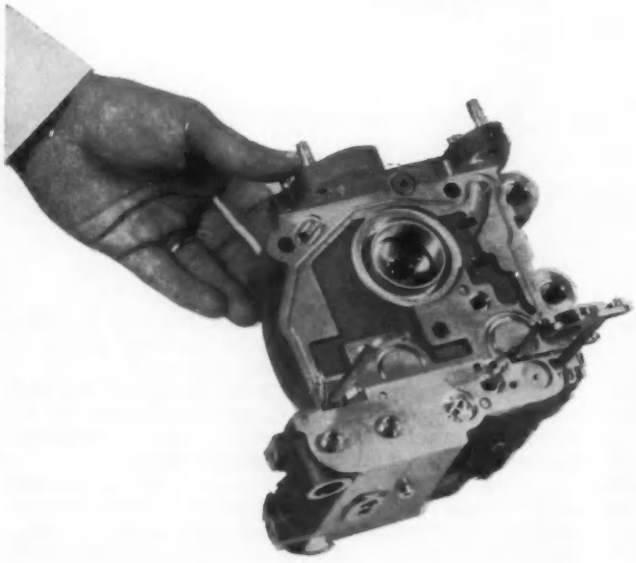


Fig. 5 — Adapter for mounting 1910 control unit to particular engine.

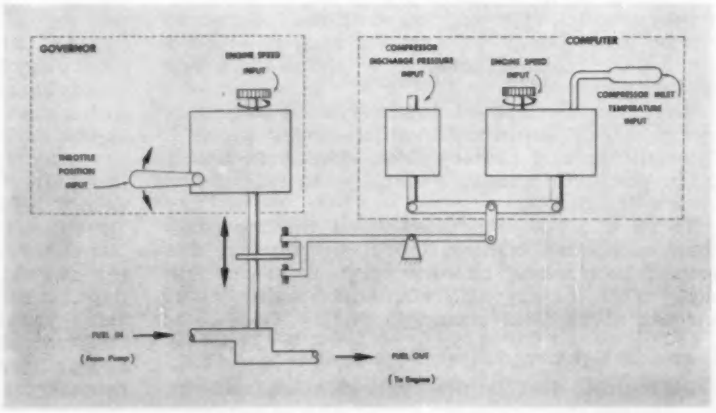


Fig. 6 — Block diagram for 1910 unit.

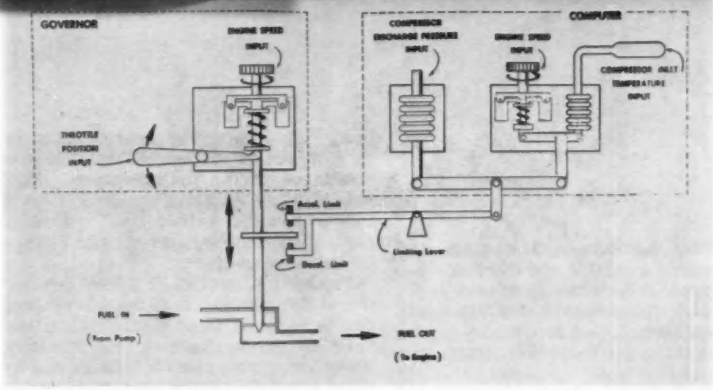


Fig. 7 — Simple schematic for 1910 unit.

2 new fuel controls . . . continued

tion, the bellows will expand, the right-hand side of the limiting lever will be raised, and the acceleration limit screw will permit the governor to move the fuel valve to increase engine fuel flow. When the new requested speed is reached, the governor will take over and close the fuel valve.

On the surface, it may seem that this simple schematic does not multiply the compressor discharge pressure function by the speed and temperature functions — that the schematic shows them to be additive. Actually, the output of the compressor discharge pressure bellows is connected to a logarithmic cam, as are the speed and temperature functions. The computer output is actually connected to an adding link, which has two such cams as its inputs. Since, when we add logarithms we actually multiply, the computer output is the function needed: CDP $\frac{N}{\sqrt{\theta}}$, where CDP is the compressor discharge pressure, N is the compressor speed, and θ is the ratio of compressor inlet temperature in degrees Rankine to a standard day temperature of 518 R.

It happens that the fuel flow requirements of a high compression ratio engine cannot be accurately described by any simple linkage, and a three-dimensional cam is necessary for the $N\sqrt{\theta}$ dodging of stall (Fig. 8). In the type 1910 this cam rotates with speed, and the follower slides across the cam with temperature. The cam is cut to have the θ in its contour. In previous fuel controls the cam moved axially with temperature under the followers.

Fig. 9 shows the fuel flow schedule.

All low force servo valves are rotated, thereby increasing their sensitivity to input signals and decreasing their sensitivity to any contaminant that might be in the oil. A gear pump supplies Dow-Corning QF–1–0026 at 200 psi to the servo valves, which boost the small input forces to high levels to overcome friction and loading forces. The output shaft to the fuel valve has 35 in.-lb of torque available, for instance, to shear any dirt that might otherwise tend to jam the valve. This torque can easily be doubled by just raising the pump relief valve setting. The external fuel valve permits easy conversion to gaseous fuels.

Compressor inlet temperature is sensed by a gas-filled probe, which produces a force proportional to temperature. This force is balanced by a spring, which is loaded as the cam followers move across the cams.

Compressor discharge pressure is sensed by a bellows, which produces a force proportional to pressure.

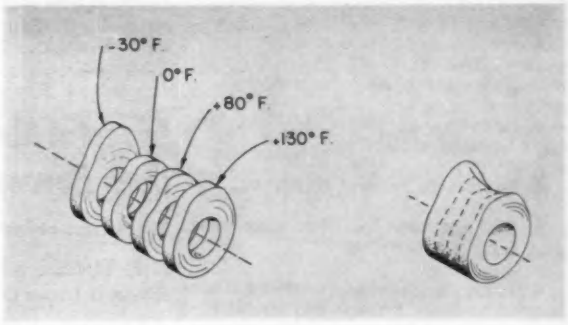


Fig. 8 — Three-dimensional cam.

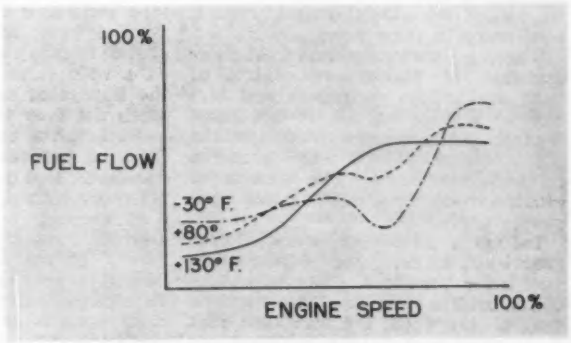


Fig. 9 — Typical type 1910 acceleration fuel flow schedule.

Throttle movement rotates a cam, which sets the force output of the governor speeder spring against the governor weight force. An isochronous governor is provided, which makes space available to change to a droop-type governor, should a particular application make this desirable.

A typical free turbine application would find the requested power turbine speed and actual speed being compared by a governor that sends an error signal to the throttle shaft of the gas generator control. The gas generator would then accelerate or decelerate until the engine airflow provided the requested free turbine speed. The computer would act in the normal way to protect the gas generator during the speed transition. The free turbine governors, can be chosen from a series of standard industrial governors, including simple droop, isochronous, and load-sensing types; the choice being dependent on the transient load characteristics and requirements.

To Order Paper No. 398E . . .
from which material for this article was drawn, see p. 6.

Heat Treat Developments Match Other Metal Advances

Based on report by panel secretary

C. E. NEWMAN
Surface Combustion Division,
Midland-Ross Corp.

HEAT TREATMENT is keeping pace with other advances in metal technology. New developments include:

1. Quality quenching systems.

2. New gear-hardening methods.

3. Selection of materials based on heat treating capabilities.

4. Factors to control distortion.

5. New methods for improving wear and fatigue properties.

Quality quenching systems are needed to meet present-day metal requirements. Additional safety devices are needed for these systems — particularly a device for detecting water in quench oil. Development work is continuing in these areas.

There is growing interest in the importance of atmosphere control of both atmosphere generators and furnaces. Widespread use of dew point control and increasing interest in the measurement of CO_2 by infra-red methods continues. The success of either system, however, depends upon proper application.

Induction hardening of large spur gear teeth by scanning each tooth is now being practiced. The advantage of this system is the hardening pattern that is developed, including the root area. The cost of the equipment is said to be reasonable but because of the speed of operation, its greatest application is low volume production.

In the selection of materials, the limitation of a sound specification is based upon what the end product must do and the availability of the proper heat treating equipment. The use of carbon-based steels instead of alloy-based steels will result in about a 10% decrease in the base price of steel alone, and since the chemistry extras are much lower in carbon-base steels the price differential will generally be 25% or more. This cost reduction can be achieved when the properties developed by the carbon base steel will satisfy engineering requirements.

While distortion is of major concern to every heat treater, certain factors can be controlled to minimize bad effects. These factors include good forging and machining practices and good premachining heat treatment.

Liquid nitriding improves wear and fatigue properties of steel for certain applications. Besides excellent wear and fatigue properties other superior properties include anti-galling and anti-seizing qualities and freedom from distortion. The process is said to be applicable to carbon and alloy steels, stainless steels, alloy tool steels, as well as ductile iron, malleable iron, cast steel and cast iron.

(Based on report of discussion at panel on Keeping Pace in Heat Treating — O. E. Cullen, Surface Combustion Division, Midland-Ross Corp., chairman.)

Impact of Numerical Control Goes Beyond Cost Savings

Based on report by panel secretary

J. P. BUNCE
Kearney & Trecker Corp.

METALWORKING machine operations in small or medium sized lots can be performed effectively on tape controlled machine tools. Substantial cost reductions have been proved in many manufacturing plants on a wide variety of jobs. However, the impact of numerical control extends not only to reduction of direct manufacturing costs; but also into the fields of product design, engineering standards, tool design, production and inventory control, and quality control.

At present, numerically controlled machine tools are performing a wide variety of operations normally performed on conventional machine tools. Tape controlled machines available include upright and horizontal drilling and tapping machines, horizontal and vertical boring machines, knee and bed type milling machines, engine and turret lathes, grinding machines, as well as punch presses, inspection machines, and accessory units for various conventional machine tools.

A fundamental principle contributing much to the effectiveness of tape controlled machines is the simplification of cutter-guiding elements on the work holding device. Generally, this principle permits fast, economical integration of engineering changes, because machine control tapes are readily altered.

While these machines do not generally remove metal at a faster rate than conventional machine tools, operations are generally completed more quickly because of the increased portion of time spent actively cutting chips. Detailed operations are performed in the correct sequence, with the proper tool operating at the right cutting speed and feed.

Quality of workpieces is usually higher with tape controlled machines because generally fewer setups are used. This provides greater accuracy in the surface-to-surface relationship generated during the operation. Also, machine positioning movements are tape controlled rather then manually controlled, thereby eliminating chance of operator error.

Production control problems are reduced for several reasons. Inventory can be reduced because machining lead time is substantially lower resulting from fewer workpiece setups as well as more effective utilization while the job is being run. Loading and scheduling is reduced because generally a smaller volume of work is in the shop.

Material handling costs are reduced because of lower inventory and fewer material moves between operations.

Generally, the skills required to install and operate tape controlled machines efficiently are the same normally required for job shop machine operations. Some additional skills may be necessary for maintaining the more complex hydraulic and electronic components.

Tape controlled machine tools have reduced floor-to-floor manufacturing times 30–50% compared with conventional methods. Some users have reported much higher savings whereby the cost of the machine tool was recovered solely on the basis of the reduction in work holding device costs alone.

(Based on report of discussion at panel on Tape Controlled Machining in One Easy Lesson — or Eventually, Why Not Now? — J. S. Randall, Kearney & Trecker Corp., chairman.)

Data Processing Aids Warehouse Operations

Based on report by panel secretary

J. D. SCHMANK
Chain Belt Co.

INSTALLATION of warehouse data processing systems is resulting in dollar savings through better scheduling, "automatic" paperwork, and increased speed. In addition, the computer can be used to determine the most efficient type of warehouse system for a given operation.

Typical warehouse operations range from an operation of 3,000 transactions per day to one of 200,000; from 10 to 17 warehouses handling from 3,000 to almost 400,000 different items. Data processing equipment varies from simple punched card equipment to an operation using two IBM 705 computers.

Data processing equipment has resulted in major savings. For example, the clerical work of writing factory replacement orders has been mechanized. The largest system produced savings approaching $1,000,000 per year based

Companies Turn to Computers For Requirements, Scheduling and Forecasting

Based on report by panel secretary

C. L. NEER
A. O. Smith Corp.

MORE and more companies are using computers for coordinating sales forecasts with building requirements, production schedules, and financial forecasts.

One company has their entire steel procurement program on the computer. From customer schedules the computer takes over and prepares and updates steel inventories, absorbs all engineering changes, parts lists, raw material lists, and computes steel requirements and parts requirements both purchased and manufactured. The computer also prepares management-by-exception reports showing inactive items, obsolete items, when to expedite steel, and the best possible steel substitutions to use when substituting.

Using this wealth of information, the computer also spits out preprinted and prepunched sched-u-graph tickets, move tickets, productive labor tickets, pickling forecasts, manpower requirements, press requirements, and various other manufacturing reports necessary to the scheduling of shop operations.

At year end, new standard costs are developed using the computer. Routing changes and sheets are issued through the computer program. This company is also using linear programming techniques in stock sizing of nonstandard steel items.

Another company is contemplating using computer simulation routine in scheduling shop operations. They also plan to use the computer for determining economical order quantities. This is made possible by the ability of the computer's internal storage or memory facilities to accumulate parts usages.

(Based on report of discussion at panel on Coordinating Sales Forecasts With Building Requirements, Production Schedules, and Financial Forecasting — **W. M. Harris**, A. O. Smith Corp., chairman.)

primarily on reduced staff, forms cost, and machine rental.

Systems employ mechanical means to determine "how much to order," "when to order," and automatically prepare the paper work to implement these functions. The systems, by and large, integrate these functions with billing. A wealth of by-product data is made available which is beneficial in production control, accounting and market and sales analysis, to produce both staff reductions and better control.

Conventional punched card equipment can be used to do the data processing, but, computers make it possible to speed up these functions and expand the scope of operations. The computer is not merely a record-keeping machine, however. Forecasting and the determination of safety stock levels and economical order quantities are common practices.

Also, the computer is a valuable system design tool. Simulation can be used to help the manufacturer find the system best suited to his needs. Two, three, or four years of warehouse operations can be compressed into a few minutes running time on the computer. The computer results show what would have happened if a particular system design were used.

The major problems facing users of data processing for warehousing are:

1. Maintaining a high degree of accuracy and timeliness of input information.
2. Selecting output requirements based on actual value to the organization.
3. Training supervisory and management levels to achieve a better understanding and more effective use of data processing.

(Based on report of discussion at panel on Profitable Warehouse Operations With Data Processing — E. M. Rhodes, Chain Belt Co., chairman.)

Spectrographic Control In Motor Truck Maintenance

Based on paper by

J. W. RIESING
Pacific Intermountain Express Co.

A SPECTROGRAPHIC laboratory system of truck maintenance control can be quite effective, especially when used in conjunction with other methods of control.

In one large trucking company where this combination of controls is used, the spectrographic laboratory receives a one-pint oil sample from each diesel engine in the fleet every 7500 miles. This sample is drawn from the oil pan through the dipstick hole, at a level governed by the length of the dipstick.

The laboratory's first move upon receipt of the sample is to post the information furnished by the shops on a permanent record card. This information consists of the equipment number, station at which the sample was taken, oil and engine miles, service performed, and amount of oil consumed in a given mileage.

A direct reading Spectrometer is used for tracing metallic contaminates in the oil that are indicative of engine wear. Since various parts of an engine contain different metals or alloys, an abnormal amount of any trace element warns that trouble is developing. This instrument is calibrated to trace nine elements: iron, lead, copper, chrome, tin, silicon, aluminum, silver, and nickel. These elements were selected because they are present in the composition of the various engine parts.

The total time involved for a spectrographic analysis is approximately 1⅓ min: 10 sec for loading the sample, 40 sec for completion of the exposure cycle, 20 sec for the measure cycle, and 10 sec to record the results from the various clocks. When the analysis indicates worn bearings, blowby, worn bushings, air cleaner malfunction or timing gear wear, the operator places the results aside for immediate reporting. Reports are sent to the shops by teletype or telephone.

The sample is then taken to the physical test lab where a series of five tests are performed to determine if the oil is contaminated by diesel fuel, sludge, fuel soots, acids or water. Approximately 40 min are required to complete these tests.

Through experience, limits for each of these contaminants have been developed. Fuel dilution will lower the flash point and viscosity. Petroleum naphtha insolubles will increase when fuel soot or sludge is present. If water is in the oil, it will become apparent during the flash test. The amount of water present is determined through distillation. Acidity is determined by a standard methyl red indicator. Upon correlation of the results of these tests, reports are then sent accordingly.

■ **To Order Paper No. 388B . . .** from which material for this article was drawn, see p. 6.

Preignition-Causing Deposits Are Different

Based on paper by

BURZOE K. GHANDHI
Outboard Marine Corp.

PREIGNITION-causing deposits appear to be small, glasslike, shiny, hard beads, as compared with the black and either light and powdery or cornflake texture of normal combustion-chamber deposits.

The preignition-causing deposits, which are present almost anywhere on or near the spark plug, can be either round or of an amorphous nature. Some are firmly bonded and some can be removed with a fine wire. Removing these deposits will often restore a preignition-causing plug to normal operation.

Chemically, these deposits can be quite varied. Lead is usually the base constituent, but iron, zinc, nickel, phosphorus, and copper are also present. Minor constituents include silicon, magnesium, aluminum, silver, calcium, and chromium. Some of these come from the fuel and oil additives. The aluminum probably comes from the engine. X-ray diffraction and other tests indicate that substantial amounts of lead bromide oxide and lead hydrogen phosphate are also present.

■ **To Order Paper No. 371C . . .** from which material for this article was drawn, see p. 6.

Deposit-Tendency Index Developed for Jet Fuels

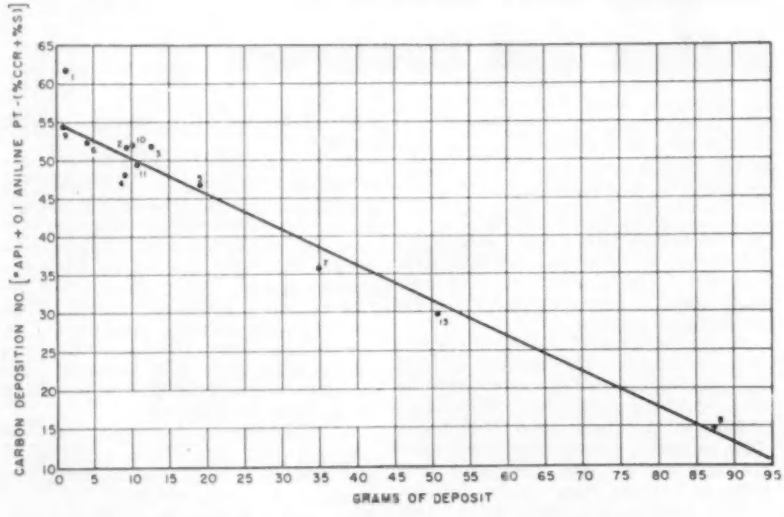


Fig. 1 — Carbon deposition number versus weight of carbon formed in standard combustion liners of Boeing 502-6 gas turbine after 5 hr of operation at full load (12 fuels studied).

Material drawn from

SAE Baltimore Section paper

Based on paper by

J. R. BELT
U. S. Naval Engineering Experiment Station

A DEPOSITION-tendency index — designated the "C number" — has been developed that appears to predict the deposit-forming tendency of jet turbine fuels quite closely . . . thus allowing the fuel properties required for deposit-free combustors to be defined.

This index number is based on easily measured properties — API gravity, aniline point, sulfur content, and carbon residue on 10% bottoms. Its formula is as follows:

C = API gravity + 0.1 aniline point − (% sulfur + carbon residue on 10% bottoms)

Fig. 1 shows the correlation between the C number and actual deposits in combustor liners in a Boeing gas turbine after 5 hr of operation at full load.

■ **To Order Paper No. S305 . . .** from which material for this article was drawn, see p. 6.

Fuels, Oils Ready For 12/1 CR Engines

Based on paper by

P. E. HAGSTROM, E. J. PEARCE, and W. D. PRESTON
Sun Oil Co.

PROPERLY designed fuels and oils are commercially available or are potentially available to permit engines with compression ratios at least as high as 12/1. This is an important overall conclusion drawn from tests conducted with 17 cars in 414,000 miles of actual road work.

The gains to be had in thermal efficiency from raising compression ratios up to 17/1 have already been established. The problem of rumble with high compression ratios has also been defined and explored. Much of this work, however, was done with engines mounted on dynamometer test stands.

Road tests reveal octane requirement in terms of performance to correlate well with compression ratio (CR) up to 15/1. The average 12/1 car can run on fuels of 100.5 Research octane quality; the majority of 12/1 cars are satisfied with fuels of 101–102 octane quality and moderate sensitivity, and all 12/1 cars should be satisfied with 104–105 octane quality.

Octane requirement increase becomes smaller with CR increases up to 10/1 then levels off at 2–3 octane numbers up to 15/1, therefore ORI is of minor importance.

TEL a Rumble Product

With normal leaded commercial fuel and a multi-graded oil, the use of phosphorus additive in the fuel can prevent rumble in engines up to 14/1. A fuel with 0.3 theory appears to be adequate for most 12/1 cars under favorable operating conditions. With a 15/1 car, rumble could not be prevented with phosphorus even to the amount of 2.0 theories. The only fuel that could prevent rumble was an unleaded, high-octane blend. TEL is a major contributor to rumble.

Fuel hydrocarbon composition is important in the rumble problem. Aromatics promote rumble and phosphorus additives are needed to offset their adverse effects. Oils, too, have an effect on rumble. The higher the CR, the higher the volatility of the oil must be to keep out rumble. Of all the oils tested, 5W-20 gave the best antirumble performance.

Tests brought forth no evidence that mechanical failures were caused by rumble. They also made clear that hot starting, part-throttle knock, and spark plug fouling were not major problems with high-compression engines.

■ **To Order Paper No. 438B . . .** from which material for this article was drawn, see p. 6.

Long Life for Alternators

Based on paper by

W. C. EDMUNDSON

Delco-Remy Division, GMC

Based on material drawn from an SAE Texas Gulf Coast Section paper

TO INCREASE the life of alternators, limitations on the lives of the following components must be lifted:

- Bearings.
- Brushes.
- Voltage regulators.

Bearing Life

The life of the ball bearings is usually limited by the life of the lubrication supplied for the bearings. In the oil-cooled generator used on buses, the bearings are lubricated by the engine oil system, so the lubrication limit is removed. The bearing life for this generator is expected to be one million miles unless the bearings are ruined by foreign matter in the oil. This type of generator is too expensive to be used for normal truck and commercial applications. Accordingly, a grease reservoir construction appears to have the best possibility for use on trucks and off-highway equipment. The construction shown in Fig. 1 has been field-tested on high-duty trucks and appears to be satisfactory for 250,000–300,000 miles of operation without relubrication. D-c generators utilizing this bearing construction have been in production for over one year and alternators with a similar construction are also now available.

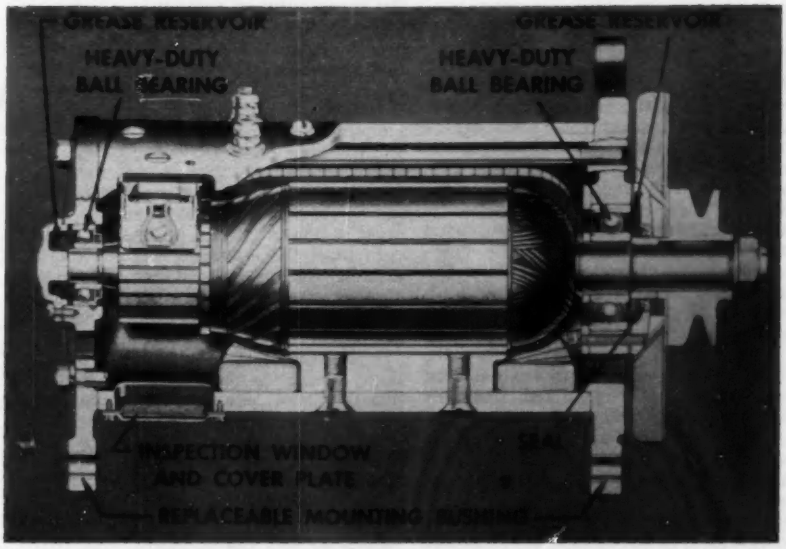


Fig. 1 — Generator with grease reservoir construction appears to be satisfactory for 250,000–300,000 miles without relubrication.

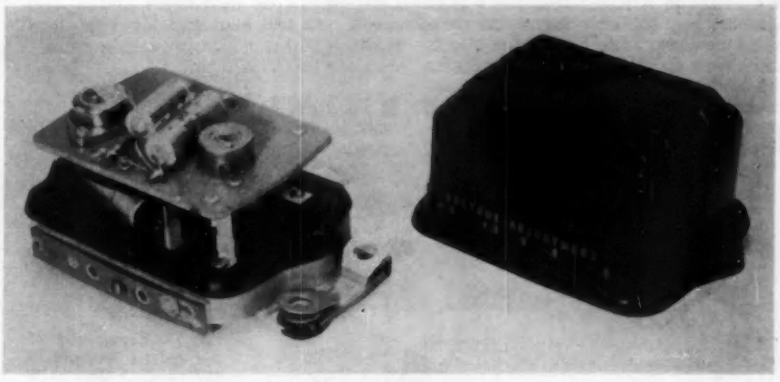


Fig. 2 — All-transistor voltage regulator has no moving parts.

Brush Life

The brush life can be extended through use of longer wear length on the brushes, constant tension brush springs, and reduced diameter slip rings to keep the rubbing velocity low. These features reduce the mechanical wear, but, unless electrical arcing is prevented, the brush life still will not be long enough.

Arcing can result from two causes, one of which is high current density in the brushes and the other is a separation of the brush and slip ring from vibration of the machine or an out-of-round condition of the slip rings. Both of these conditions can be overcome very effectively by the use of a double set of brushes set at 90 deg to each other. The extra area reduces the current density, and no vibration or high spot on the slip ring can lift both brushes on the same ring out of contact at the same time.

These features have been incorporated in a recent design that, in field installations, has already operated for more than 100,000 miles. The indications are that these installations will give over a half million miles of running at the present rate of wear. Earlier designs had gone 250,000 miles without wearing out the brushes.

The other enemies of long brush life are dirt, oil, salt splash, and other types of foreign matter, which either act as abrasives between the brush and the ring or tend to cause the brush to hang up in the holder. The construction shown in Fig. 1 utilizes an enclosure around the brushes and slip rings with close running clearances to prevent the entry of any quantity of foreign material. This protection is effective in preserving the high mileage characteristic, even under adverse conditions.

Various types of brushless generators could be used, eliminating the brush wear problem altogether. It is questionable whether the increased weight and cost of such a generator would be justified, when 250,000 miles can be obtained without this expense.

Voltage Regulator

One of the severe limitations on charging system life has been the voltage regulator because, sooner or later, the contact points become oxidized. The only way known at present to get 250,000 miles of service is to get rid of the contact points, which has been done in the full-transistor regulator (Fig. 2). Field tests bear out the logic of the design, because several units already have more than a quarter of a million miles of use without attention.

■ To Order Paper No. S311 . . . from which material for this article was drawn, see p. 6.

Extended Expansion Brings Fuel Savings

Based on paper by

E. W. HUBER
Institut fuer Motorenbau Dr. Huber

EXTENDED EXPANSION, German researchers claim, should appreciably improve fuel consumption and operating characteristics of spark ignition engines. Comparative road tests conducted on two vehicles, which were identical except that one had a standard engine while the other employed extended expansion, showed the superiority of the extended expansion engine. Acceleration from 0 to 50 mph was 10–15% better, with identical top speed, 11% fewer gear changes were required, and mileage averaged more than 15% better. Both engines had the same peak power, but different torque characteristics.

In Fig. 1, the EE process is compared to the standard Otto cycle; both having the same peak compression pressure. In each case the compression ratio ε is the ratio of volumes a and b, while δ is the ratio of volumes b and d. In the cycle ε equals δ, while in the EE process δ is greater than ε.

If the heat inputs are the same in each case the entropy changes will be identical, and the only way to increase the thermodynamic efficiency is to somehow increase the t-s diagram area within the limits s_1 and s_2. One approach is to increase the compression ratio; this would raise the upper boundary of the diagram. In the EE process, the area is increased as indicated by the cross-hatched portion.

The pressures at the end of the compression stroke are kept equal by reducing the compression volume in the EE process. The compression volume v_c can be reduced and/or the compression ratio ε increased until the knock limit is reached.

To utilize the thermodynamic advantages of extended expansion the intake valve must be closed early. This gives a lower charge weight at high rpm than the standard engine, and a greater charge at low rpm. A high charge weight at low rpm results in high torque, which lowers the demands on the transmission.

If intake duration is reduced to the point where the maximum power output is 8–10% less than a comparable standard engine, the fuel consumption will be lowered by some 12–16%. This is achieved by advancing the intake valve closing by 20–30 deg, depending on engine design.

The spark advance must also be adjusted to eliminate knock. At part load there should be early ignition and constant-volume combustion with low peak pressure. This condition should also prevail at maximum power and speed. At full load and low rpm, late ignition and constant pressure combustion are recommended.

■ **To Order Paper No. 380B . . .** from which material for this article was drawn, see p. 6.

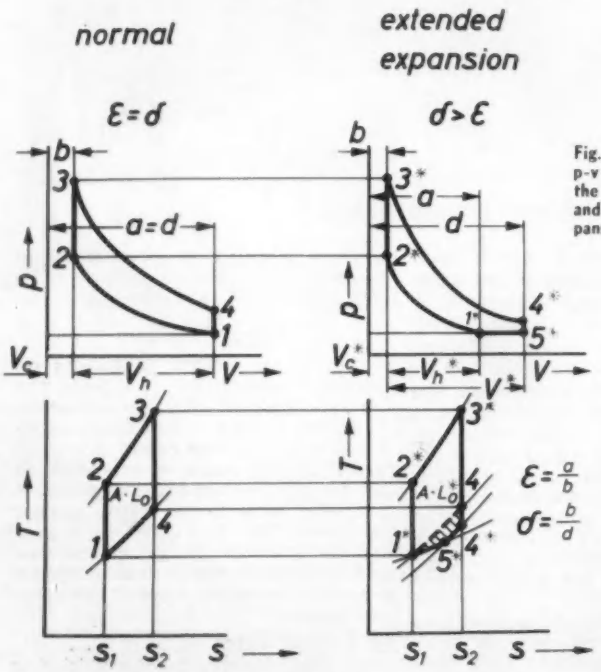


Fig. 1 — Comparison of p-v and t-s diagrams of the standard Otto cycle and the extended expansion process.

3 Areas Pose Potential Trouble Spots for Plastics

Based on paper by

K. H. WOODRICH, Woodall Industries, Inc.

WHEN designing for thermoplastics, the plastics engineer must be alert for problems caused by:

1. Temperature variations
2. Stress cracking
3. Warpage and stiffness

The thermal movement of all thermoplastics range from 1/16–3/16 in. per ft over a 100 F temperature variation. The exact amount depends upon the type of plastic and the processing technique. This movement must not be restricted. Proper assembly techniques can allow for this movement.

High and low temperature may appreciably affect the mechanical properties of the plastic material. The impact strength and stiffness must be checked at the high and low temperature the part encounters during its service life. Shape stability at elevated temperatures or heat distortion must be evaluated.

Proper design will prevent stress cracking. Localized stresses, ultraviolet exposure, and high temperature are the parameters of this phenomena.

Good assembly design can eliminate most localized stresses.

Most of the ultraviolet exposure of automotive interior parts is through glass. This means a simple addition of an ultraviolet inhibitor gives a thermoplastic material long life. However, special thermoplastic formulations are recommended for unusual applications.

High temperature exposure means that any stress cracking action will be accelerated. That is, if a part will stress crack at room temperature it will crack at a faster rate at an elevated temperature. All these problems can be investigated with accelerated oven aging, ultraviolet exposure, or end use tests.

The engineer must also familiarize himself with conditions that produce warpage and stiffness. Warpage can be caused by improper section design or processing behavior. For example, warpage can result from severe variations in material thickness. Keep part thickness as uniform as possible. Poor processing in the form of abnormal die temperatures can also produce warpage.

Stiffness is basically determined by the flexural modulus and the moment of inertia. For a given material you can't change the flexural modulus but you can increase stiffness by controlling shape. The stiffening method — ribs, corrugations, curved sections — can be easily molded in with no sacrifice in cost.

■ **To Order Paper No. 321B . . .** from which material for this article was drawn, see p. 6.

Digital Computer Evaluates Tractor-Scraper Performance

Based on paper by

D. A. LEWIS
and W. C. MORGAN
Caterpillar Tractor Co.

DIGITAL computers are being used to evaluate the performance of existing tractor-scrapers and proposed earthmoving vehicles.

The evaluation is based primarily on a cost-per-yard study, but other performance factors such as earthmoving production and acceleration are included in the calculations.

Ownership and operating costs — plus earthmoving cycles — are broken down into small segments. For each of these segments, the performance of the machine is examined. The segments are then rebuilt to give an overall performance figure.

The cost per yard is calculated by dividing the owning and operating cost of the unit (in dollars per hour) by the earthmoving production of that unit (in yards of dirt hauled per hour). Owning costs would include depreciation, insurance, and taxes. Operating costs include fuel and oil, tires (or tracks), repairs, and operator expenses.

Earthmoving production is the yards of dirt hauled per hour. This is found by determining the time required for the tractor-scraper to make a complete trip with a given payload and figuring from this how many trips can be made in an hour. (When auxiliary equipment is used in conjunction with the tractor-scraper, the auxiliary's cost must be added to those of the tractor.)

To calculate the production of the equipment, it is necessary to analyze the tractor-scraper at work, that is, determine what functions the vehicle accomplishes during the various segments of the earthmoving cycle.

A typical earthmoving cycle (Fig. 1) consists of:

1. Loading
2. Maneuvering out of the borrow pit onto the haul road.
3. Accelerating, running at top speed, and braking on the haul road.
4. Maneuvering to the fill.
5. Spreading on the fill.
6. Maneuvering on the fill.
7. Returning over the fill.
8. Maneuvering on the return road (this may well be the same road as the haul road).
9. Accelerating, running at top speed, and braking on the return road.
10. Maneuvering into the borrow pit.
11. Waiting to be pushed for loading again.

The problem, then, is to simulate the performance of the tractor-scraper on the various portions of the earthmoving cycle and calculate the time required for the vehicle to traverse each. Assuming that data is available to describe the vehicle, any auxiliary equipment, the course, and the operator, this problem involves:

1. Deriving mathematical equations based on the physical laws governing the operation of the machine and its components.

2. Analysing the technique employed by the operator in driving the machine, and duplicating his decisions concerning shifting, braking, or dumping speed.

It has been found much easier to establish the effect of an individual variable, such as shift time and horsepower, on the computer than it can be done experimentally. Thus the computer represents a valuable tool to help minimize the costly and time consuming methods that have been used in the past to evaluate performance of new earthmoving concepts. Now in most cases there will be a reasonably accurate understanding of the performance of a proposed machine before it is actually built.

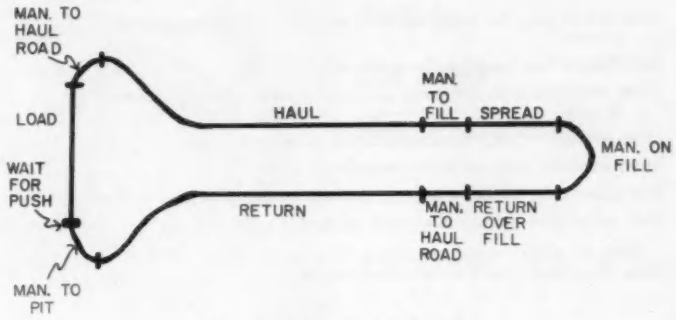


Fig. 1 — Typical earthmoving cycle.

To Order Paper No. S297 . . .
from which material for this article was drawn, see p. 6.

Unit Exchange Plan Benefits Engineering

Based on paper by

R. W. SHERK
Allison Division, GMC

THE OPPORTUNITY given engineers at the plant to see failures at first hand is one of the greatest benefits Allison has derived from its unit exchange plan for engines, QEC's and propellers. QEC literally means "Quick Engine Change." It is the power nacelle, including the engine and structural portions of the airframe, but not the propeller. With 65% of all Electra engines being overhauled at the plant, the problems of wear and failure can be examined conveniently with a full range of inspection and test facilities.

Standardization is a natural outcome of the pooling of engines in such a plan. Greater interchangeability allows more flexibility in control of the pool and also permits the job to be done with a smaller number of engines. Thus, the manufacturer has a strong incentive to push for standardization in order to operate on a smaller inventory.

One problem has been lack of complete standardization of QEC configurations. Starting systems provide an example. This requires maintaining a pool of QEC's for each airline, but change from one configuration to another can be made within a few hours if necessary.

Another problem arises from the differences in FAA authorized TBO's (time between overhaul), for the various major units and components. Allison has been working with the airlines toward approved TBO's with each component having an approved time which is in increments of the basic engine TBO. Some progress is being made, but this will probably always remain a problem.

■ **To Order Paper No. 373B . . .**
from which material for this article was drawn, see p. 6.

Table 1 — Results of Braked Runs on Wet Runway

	Distance, ft
Worn ribbed tires, full brake pressure, antiskid operating, no reverse (2 runs)	3850
Worn ribbed tires, modulated antiskid, no reverse (1 run)	3820
Worn nonribbed tires, full brake pressure, antiskid operating, no reverse (3 runs)	4000
Worn nonribbed tires, modulated antiskid, no reverse (1 run)	3460
Worn nonribbed tires, no brakes, modulated, (2 runs)	4610
New ribbed tires, full brake pressure, antiskid operating, no reverse (3 runs)	2600
New ribbed tires, modulated antiskid, modulated reverse (1 run)	2250

Note: On a dry runway, new ribbed tires and modulated antiskid, without reverse thrust would give a corresponding stopping distance of about 2150 ft.

707 Tests on Wet Runway Show Ribbed Tires Are Best

Based on a talk by

DAVID R. BLUNDELL
American Airlines, Inc.

ON wet concrete runways, ribbed tires allow a substantially shorter stopping distance than do nonribbed ones. In fact, even when the ribbed tires are worn to current limits, they provide slightly better traction than do worn nonribbed ones.

These conclusions are based on a series of braking tests with a Boeing 707–123B on a wet concrete surface. The tests also showed that:

- The reverse thrust on the fan-engine-powered 707–123B, when used in a practical way, has the ability to compensate for the poor coefficient of friction provided by smooth tires on a wet surface and thereby to restore the stopping distance to that obtainable on a dry surface without reverse thrust.
- With worn nonribbed tires, careful modulation of brake pressure can result in a substantially improved stopping distance (according to evidence based on one run), but this improvement was not obtained with the worn-ribbed tires. This discrepancy may result from pilot variability rather than from the difference in tire tread.

How Tests Were Made

All measurements were made on a consistently wet concrete surface, produced by continual rain, and were recorded by a theodolite camera. To minimize the effects of pilot skill, most of the braked runs were made with full pressure and antiskid operating. Two runs were made, however, in which the pilot modulated brake pressure to avoid excessive antiskid cycling.

When reverse thrust was used, full reverse was applied initially, and thereafter the amount of reverse was progressively modulated as forward speed diminished — to avoid ingestion and resultant surge.

The worn tires were just ready for recap, and the ribbed ones had five grooves.

Table 1 summarizes the results in terms of distance from 120 knots to rest. These have been corrected to zero wind, sea level standard day, and a weight of 175,000 lb. (At this weight 120 knots represents reference speed minus 13 knots on the 123B — and is chosen for this comparison as it represented the highest ground speed at which the brakes could be assumed to have been on — and spoilers out — in *all* the braked runs.)

Analysis of the variation of deceleration with forward speed is still in process but, using aerodynamic coefficients deduced from an unbraked, nonreversed roll-out, the following effective μ values have been computed for 100 knots forward speed (full antiskid in all cases):

Worn ribs	0.115
Worn nonribbed	0.103
New ribs	0.215

(On a dry runway $\mu = 0.25+$ would be expected with new ribbed tires.)

The same aerodynamic data shows that the peak incremental deceleration provided by reverse thrust is equivalent to 5200–7200 lb per engine at 100 knots — or 5900 lb and 7900 lb, allowing for the residual forward thrust present when reverse is not used.

Capillary-Flow Meters Good to Measure Engine Airflow

Based on paper by

GORDON H. MILLAR, McCulloch Corp.

EMIL GILLIG, Ethyl Corp.

ARTHUR HEJDUK, Meriam Instrument Co.

FIELD experience with capillary-flow airflow meters indicates that — when properly designed — such a meter is the most versatile engine airflow measurement equipment available within the range of accuracy required.

The compactness and versatility of the capillary-flow system also provides solution to installation problems where space requirements must be met and accuracy maintained. Further exploration, however, is indicated to obtain a thorough understanding of the secondary element and its effect on the metering accuracy under conditions of severe pulsation.

It is clear that a greater knowledge of engine performance in as-installed conditions in vehicles can be obtained through use of suitable engine airflow measurements.

■ **To Order Paper No. 379C . . .** from which material for this article was drawn, see p. 6.

Dipping Primers Resist Unitized-Body Corrosion

Based on report at panel session by

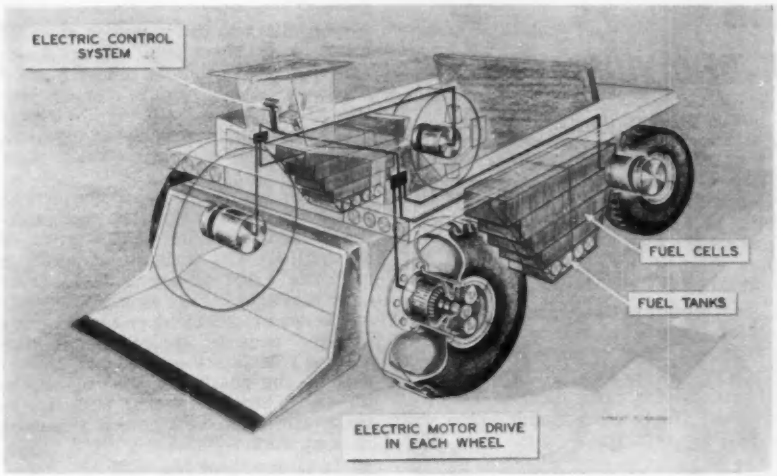
R. I. PETERS
Ditzler Color Division of
Pittsburgh Plate Glass Co.

TWO types of dipping primers protecting unitized passenger-car bodies from corrosion are:

1. Epoxy ester in organic solvents.
2. Water-reducible primers.

Each of these dipping primers has its strong and weak points. The organic-solvent-based epoxy ester deposits a film similar to presently used exterior body primers. Salt spray resistance is one of its strong points. Sags may be removed by washing with solvent before baking and the film built up again with a spraying version of the primer. The organic solvent used is good for grease and drawing compounds — therefore reasonable performance is obtained even over improperly cleaned steel. The epoxy ester organic solvent, however, presents a fire hazard, and a health hazard if adequate ventilation isn't provided.

The water reducible dipping primers obviously don't present fire hazard



Fuel-Cell-Powered Vehicle Can Have High Performance

Based on talk by

A. F. ERWIN and W. W. EDENS
Allis-Chalmers Mfg. Co.

Fig. 1 — Fuel-cell-powered electric earthmover of the future, with fuel cells and fuel in convenient locations, and with direct motor drive wheels.

THE fuel-cell-d-c-motor-drive system (Fig. 1) is one way to attain rapid acceleration and high speed in vehicles powered by fuel cells.

To show how such a system would work out in practice, let us compare it with the internal-combustion engine. The latter has a low overload, or low maximum torque capability, and must, therefore, have a high rated horsepower in order to supply the torque required for rapid acceleration. The internal-combustion engine also requires many accessories that increase disproportionately in power consumption at high engine speed. These include the generator, pump, fan, and certain torque converter transmissions.

Furthermore, the efficiency curve of the gasoline engine usually peaks out near maximum horsepower at high speed, so that its efficiency suffers at the lower power and lower rpm of the normal cruise condition. For instance, a 4000-lb automobile requires only 80 hp to travel at 85 mph.

Conversely, the fuel-cell-d-c motor drive can eliminate the parasitic accessories; the efficiency of the fuel cell rises sharply as the load is reduced, and the d-c motor can be designed for high efficiency over a wide range. Most important, however, is the greater overload capability of the fuel cell for short-term power demands, coupled with the high maximum torque capability of the d-c motor for similar periods. Where the maximum torque capability of a gasoline engine may be 30% above rated torque, the d-c motor can provide over 250% of rated torque for the time required to accelerate a vehicle.

problems. In addition, the water reducible primers present less of an odor than the organic solvents. They are highly resistant to salt spray and humidity when properly baked.

Both solvent-based and water-based primers are subject to vapor washing. This phenomenon is caused by solvent evaporating from a warm surface and condensing on a cooler one, flowing down, and carrying paint with it. Since any practical convection or radiation type oven will heat outer shell parts or those nearest the radiant source before inner surfaces, there is always the danger of vapor washing. It's possible to remove solvents from inner chambers by passing air through at room temperature and evaporating the solvent but the system required is unwieldy.

One way to minimize vapor washing is to dip at lower viscosity. More of the paint will drain from box members, and therefore will be less apt to evaporate and condense. Another practice is to spray a reinforcing coat of paint or other rust inhibitive on the rocker panels after baking operations are over. This replaces paint through vapor washing. There is the danger, however, of a given part being vapor washed again with repeated baking.

Diesel Not Yet Threatened By Turbine

Based on paper by

KENNETH W. SELF
Freightliner Corp.

GAS TURBINES will come into use to power trucks in the few instances where abnormally high horsepower is needed, but for the next 15 years the diesel engine will be the dominant engine and the V-type will gain rapidly in popularity.

Heavier payloads and higher road speeds mean higher horsepower engines. The additional horsepower can be gained by several means — by greater displacement, by higher engine speeds, and by supercharging. The most practical, over-the-road engine is one with sufficient displacement to give the needed horsepower without supercharging or substantial increase in engine rpm, and sufficient power to permit cruising at decreased rpm for fuel economy. Increasing horsepower by increasing displacement, without too much gain in engine size and weight, is practical only to a certain point. Beyond that point, supercharging becomes economical.

The exhaust turbocharger is a practical means for obtaining more horsepower from the same size of engine. Improvements made recently and those to come, indicate that turbocharging will be important for engines over 300 hp.

With the V-8 engine's shorter stroke, higher rpm can be had with the same piston speed. With better balanced components and higher precision parts, engine life will be comparable or better even at the higher rpm. Increased rpm for short periods will provide the means for getting increased horsepower for picking up gears and maintaining minimum speeds on hills, then cruising with more moderate rpm's for fuel economy and long life.

The V-design makes it possible to build a more rugged engine block with a shorter, huskier crankshaft. And it offers a means for getting more horsepower from an engine shorter and lighter in weight than any in-line engine of comparable horsepower.

■ **To Order Paper No. 384A . . .** from which material for this article was drawn, see p. 6.

Nitric Oxide in Trace Amounts Can Affect ENGINE KNOCK BEHAVIOR

Based on paper by

D. B. WIMMER
and L. A. McREYNOLDS
Phillips Petroleum Co.

THE destruction of tetraethyl lead in an engine can be controlled, under some circumstances, by trace quantities of nitric oxide.

This is one of the conclusions drawn from an initial survey of the effects of nitric oxide on engine combustion behavior. (Nitric oxide is the only nitrogen oxide present in significant quantities during an engine cycle.) Some of the other conclusions drawn from this survey are:

- The quantity of nitric oxide normally present during compression is sufficient to alter observed combustion behavior markedly. With certain fuels it is a decided proknock agent. With other fuels it apparently has little effect. In no case were antiknock effects observed with concentrations representative of the nitric oxide ordinarily present.
- Tetraethyl lead and compression ratio increases tend to increase the proknock effect of nitric oxide.
- There appears to be a distinct tendency for more pronounced proknock effects from nitric oxide with fuel-lean mixtures.
- Nitric oxide effects become increasingly detrimental as engine parameters are changed in the direction of greater thermal efficiency.
- Corollary to the proknock effect of nitric oxide, there is a distinct tendency for it to promote precombustion reactions, once they have started. Nitric oxide does not appear to trigger precombustion reactions in systems where little or no precombustion reactivity is present.
- Nitric oxide cannot validly be neglected when considering the factors influencing the combustion behavior of an engine. The ultimate importance of nitric oxide effects in influencing such practical results as octane blending behavior, knock rating differences between engines, etc., is not known with any certainty at present. Nevertheless, the possibility that nitric oxide exerts some degree of influence in these areas can be inferred from the present work.

■ **To Order Paper No. 380E . . .** from which material for this article was drawn, see p. 6.

Compound Design Benefits With Aluminum Engine Use

Based on paper by

JAMES M. SMITH
Aluminum Co. of America

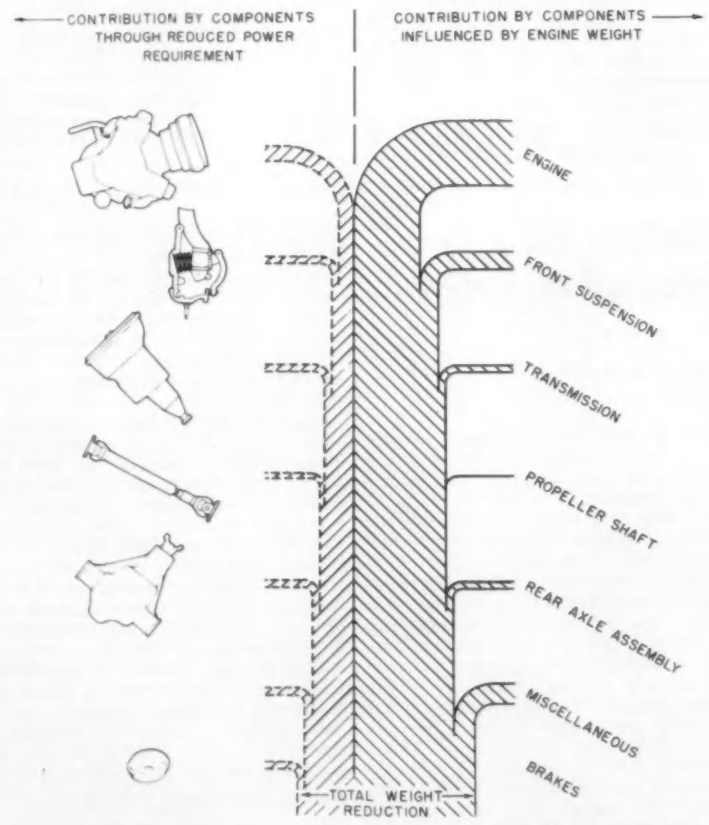


Fig. 1 — Possible compounded vehicle weight reduction in a car using an aluminum engine

MERE replacement of a cast iron engine by an aluminum design cannot achieve the ultimate in weight and cost reduction and performance.

If, for example, the weight distribution of a modern 4000 lb car is 56% front and 44% rear, an easily attainable weight saving of 180 lb in the engine changes the distribution to 54–46 in a desirable direction from the standpoints of ride and control.

Also, to carry the engine weight reduction to the parts immediately affected, the front frame section and suspension parts support less weight . . . and are subjected to less shock from negotiating road obstacles. They may, therefore be made lighter in section, adding their weight saving to the front wheel load reduction.

Then the wheels, supporting less weight, may be made lighter — and smaller-sized tires may be warranted. . . . A further weight saving in steering gear housing and linkage is permissible, too. (Fig. 1 graphically presents a conception of these and other cumulative effects of weight savings in the engine upon vehicle weight.)

An automobile engineered to take advantage of every possible saving accruing from use of an aluminum engine might well be found to have no cost premium . . . and the car owner could hopefully expect better fuel economy and performance.

■ **To Order Paper No. 385A . . .** from which material for this article was drawn, see p. 6.

SAE NEWS

- Proposed Amendments to the SAE Constitution 100
- Top Latin American Engineers to Talk at SAE's Pan American Day 103
- Keep SAE Young, Kucher Urges at Regional Section Officer Conference 103
- SAE National Meetings 104
- New SAE Reports 105
- CEP News 106
- VERSATILE EARTHMOVER Highlights SAE Heavy Duty Vehicle Meeting in Milwaukee 108
- Rambling through the Sections 118
- SAE Section Meetings 118
- SAE Members 120
- New Members Qualified 141
- Applications Received 145

Proposed Amendments to the

THE following proposed amendments to the SAE Constitution are being submitted to the voting members of the Society "at least sixty days before the next Annual Business Meeting . . ." in accordance with C 52 of the Society's Constitution.

These proposed amendments and explanatory comments thereon are the result of a review of the Constitution undertaken by the Constitution Committee and submitted to the Board of Directors, who directed that the proposals be presented to the voting members.

Among the proposals are amendments to include reference to the Society's initials in the Constitution, to reword the section on qualifications for Associate grade of membership and to add a paragraph regarding the distribution of the Society's assets in the event of dissolution. The remaining amendments, in most instances, are merely to bring the Constitution up to date with current practices, to delete from the Constitution some of the language that was necessary during the transitionary period to put the Planning for Progress proposals into effect, and for clarification. They represent no major changes in the Society's operations, and explanations for each of the proposed amendments appear under the individual paragraphs.

As required by the Constitution, the proposed amendments will be presented to the membership at the Annual Business Meeting to be held in Detroit on Monday, January 8, 1962; and, if at that time twenty votes are cast in favor of such submission, the proposed amendments shall subsequently be submitted by letter ballot to all members entitled to vote.

Proposed Amendments to the SAE Constitution

(Proposed additions are underlined ———————. Proposed deletions are crossed out ----------.)

C 1 The title of this Society is "SOCIETY OF AUTOMOTIVE ENGINEERS, Inc." The official abbreviation of the Society's name shall be "SAE."

Explanation: This amendment was proposed by the Constitution Committee in line with getting the initials SAE and the SAE emblem copyrighted. The Council at its January 15, 1960, meeting approved of the Constitution Committee recommendation and agreed that the amended language should be prepared for action "at the proper time."
At the time the amendment to C 1 was acted upon, the Constitution Committee also recommended that the Constitution or the By-Laws be amended to formally specify the nature of the SAE emblem as to design, shape and color. This will be provided for in the By-Laws.

C 3 The principal means for accomplishing this object shall be ~~the~~ holding ~~of~~ meetings for ~~the~~ presentation and discussion of professional papers, ~~the development of~~ developing technical reports including engineering standards and recommended practices, and ~~the publication and distribution of same~~ publishing and distributing such papers and reports.

Explanation: The proposed changes as indicated above are for clarification and better language.

C 20 Associate grade shall be composed of persons ~~not less than~~ 26 years of age, or older who are ~~not eligible for Member grade but who are qualified, by reason of position or experience,~~ competent by virtue of experience, education or responsibility to cooperate technically with ~~automotive~~ engineers in automotive or related engineering work or who, in the opinion of the Board of Directors, will further the objective of the Society.

Explanation: The above amendment was proposed by the Membership Grading Committee at the January 13, 1961, Board of Directors' meeting. The Board of Directors approved of the recommendation that this amendment be considered the next time the Constitution is amended.

In presenting its recommendation, the Membership Grading Committee advised that the proposed amendment to C 20 of the Constitution was to remedy the feeling that an Associate member is a second rate member, which can be read out of the current language. In other words, C 20 implies to some that an applicant who doesn't satisfy the requirements for Member grade is relegated to a "secondary" membership status by being elected to Associate grade. The proposed amendment to C 20, as developed by the Membership Grading Committee, attempts to define the Associate grade to members in more positive terms and eliminates the negative interpretation in the current language.

C 26 The Board of Directors may, ~~at its discretion,~~ by a three-fourths ballot vote of its members, change any ~~then existing~~ schedule of dues for membership, and may provide for ~~the~~ payment of dues in installments. No increase in dues shall be effective unless announced in the official publication of the Society, or by letter to the membership, at least one month prior to the beginning of the period in which the increase is to be first effective.

Explanation: The proposed changes were suggested by a member on his ballot on the amendments which became effective on January 11, 1960. These changes propose eliminating what appears to be redundant language.

C 35 The Past-Presidents of the Society shall constitute the Past-Presidents' Advisory Committee. This Committee shall meet once during the Annual Meeting and at such other times

SAE Constitution

and places as it may elect. This Committee shall provide for its own organization. The Committee may consider any matter referred to it by the Board of Directors, or any other matter which in its opinion concerns the interests of the Society. The Committee may report its recommendations directly to the Board of Directors, or directly to the membership of the Society when such recommendations have the approval of a majority of the full membership of the Committee. It is the duty of the Past-Presidents' Advisory Committee, each year, to elect three delegates to the Annual Nominating Committee.

Explanation: C 35 outlines the make-up and duties of the Past-Presidents' Advisory Committee. It does not, however, mention that it is the duty of the Past-Presidents' Advisory Comittee, each year, to elect three delegates to the Annual Nominating Committee. The only reference to the fact that the Past-Presidents' Advisory Committee elects three delegates is in C 45, which explains the method of getting the delegates and alternates for the Annual Nominating Committee.

C 45 The Annual Nominating Committee of the Society shall consist of six delegates-at-large, and one delegate from each geographical Section of the Society. The delegates-at-large shall be elected as follows:

Three by the Past-Presidents' Advisory Committee.

One each by the Engineering Activity Board, the Technical Board, and the Sections Board.

The Section delegates shall be elected by and from each Section. Each Section and Board may elect, in addition to a delegate, a first alternate and a second alternate. The first alternate shall serve in the absence of the delegate, and the second alternate shall serve in the absence of both the delegate and the first alternate. All delegates and alternates to this Committee shall be voting members of the Society. Neither a delegate nor an alternate may be represented by a proxy at a meeting of the Nominating Committee.

The names of all delegates and alternates shall be submitted to the Secretary not later than the date established in the By-Laws.

The work and procedure of the Committee shall be as defined in the By-Laws.

The Annual Nominating Committee shall select nominees for President, Treasurer and four Directors. ~~In the nominations for the first election of Officers after paragraph C-39 becomes effective, the Committee shall select nine nominees for Directors; one to serve for a term of one year; four to serve two year terms, and four to serve three-year terms.~~

Explanation: Inasmuch as the new method of selecting Directors on a three-year basis has been established and the transitional period is over, the last sentence in the last paragraph is no longer necessary.

C 46 Each year the Engineering Activity Board, the Technical Board and the Sections Board shall each elect from its own members a Nominating Committee of voting members, and each of these Nominating Committees shall select one nominee for the Board of Directors. ~~In the nominations for the first election of Officers after paragraph C 39 becomes effective, the members of each Nominating Committee shall select three nominees; one to serve a one-year term, one to serve a two-year term and one to serve a three-year term.~~

Members of these Nominating Committees may not be represented by proxy at meetings of such Committees.

The work and procedure of these Nominating Committees shall be as defined in the By-Laws.

Explanation: Inasmuch as the new method of selecting Directors on a three-year basis has been established and the transitional period is over, the last sentence in the first paragraph is no longer necessary.

C 52 An amendment to this Constitution may be proposed by a majority vote of the Board of Directors obtained either at a Board of Directors meeting or by letter ballot of the Board of Directors taken at the request of the President, or by any voting member who secures authorization. Authorization of a voting member to propose an amendment shall consist of a petition in which the amendment is set forth bearing the signatures of twenty voting members. The proposed amendment, accompanied by any comment the Board of Directors wishes to make, shall be mailed by the Secretary to each member of the Society entitled to vote or shall be printed in the official publication of the Society at least sixty days before the next Annual Business Meeting or the next Special Business Meeting called for the purpose of amending the Constitution of the Society. At this Business Meeting such proposed amendment shall be presented for discussion ~~and final amendment,~~ and shall subsequently be submitted by letter ballot to all members entitled to vote, provided that twenty votes are cast in favor of such submission. The letter ballot, accompanied by the text of the proposed amendment, shall be mailed by the Secretary to each member entitled to vote, promptly after the close of said meeting. Ballots returned within thirty days after the date on which they are mailed to the voting membership shall be counted by Tellers appointed as provided by the By-Laws. The Tellers shall announce immediately the result of the vote, which shall be mailed to the members by the Secretary. The adoption of the amendment shall be decided by a majority of the votes cast.

An amendment shall take effect immediately upon the announcement of its adoption, unless otherwise provided at the time the amendment is presented to the voting members.

Explanation: The word "voting" has been added to the last paragraph for the purpose of clarification.

The present C 52 contains an implied self-contradiction. The first and second sentences describe how a member may propose an amendment, which proposal shall be made available to every voting member of the Society at least sixty days before the Business Meeting at which the proposal is to be considered. In the fourth sentence, however, C 52 implies that an amendment to an amendment may be proposed at such Business Meeting and voted upon without prior notice to members. In order to prevent the selling of a small proportion of members attending a Business Meeting on a change or addition to a proposed amendment that is brought up to that meeting without time for proper consideration by all, it is suggested that the words "and final amendment" be deleted from the fourth sentence of C 52.

C 53 In the event of dissolution pursuant to the provisions of the Membership Corporations Law of the State of New York, the remaining assets shall be distributed in such manner as shall be approved by a Justice of the Supreme Court to one or more other nonprofit corporations or associations to be administered or used in such manner as will best accomplish the general purposes for which this Corporation was formed or for which the properties or funds are legally required to be used.

Explanation: The Society's legal counsel suggests that the above paragraph be included in the Society's Constitution and By-Laws as a restatement and clarification of existing law. The Constitution Committee recommends that this paragraph be added to the Constitution.

Coleman is 1961 Buckendale Lecturer

Wells Coleman

L. RAY BUCKENDALE LECTURER for 1961 is Wells Coleman, chief gear analyst, Gleason Works. Coleman was named by the L. Ray Buckendale Lecture Committee of which P. H. Pretz, Ford Motor Co., is chairman.

Coleman will lecture on "The Design and Manufacture of Heavy Duty Gears," a subject on which he has been actively engaged since 1945. He has written many of the technical publications issued by the Gleason works and has conducted courses in gear engineering. He holds both B.S. in mechanical engineering and Master of Science degrees from Massachusetts Institute of Technology. He has worked with Gleason ever since his graduation in 1938.

He is currently chairman of the Bevel Gearing Committee of the American Gear Manufacturers Association and has served on other important technical committees of that organization.

Coleman will present his lecturer at the 1961 SAE Automotive Engineering Congress at Cobo Hall in Detroit next January.

Indian Automobile Ancillary Productivity Team . . .

THE INDIAN AUTOMOBILE ANCILLARY PRODUCTIVITY TEAM, many members of which recently visited SAE Headquarters, hopes to become acquainted with the prevailing concepts and attitudes, methods and techniques, organizational principles and practices, and relationships which are pertinent to the level of efficiency and general industrial performance achieved in the area of their specific field of interest in the U. S. and Germany.

The team consists of responsible Indian industrial executives, technicians, and government officials. Each member of the team has been selected by the National Productivity Council for his ability to contribute to a joint analysis of factors contributing to high productivity and low cost operations which could be adapted to Indian conditions.

Members of the team are: **K. G. Khosla,** managing director, K. G. Khosla & Co., Private Ltd., New Delhi; **P. N. Menon,** technical director, Best & Co. Private Ltd., Madras; **R. N. Talwar,** sales director, Payen Talbros Private Ltd., New Delhi; **P. V. Shah,** managing director, Metropolitan Springs Private Ltd., Bombay; **H. R. Aslot,** managing director, M/s Hubs & Drums Private Ltd., Bombay; **K. Padmanabhan,** works manager, Associated Trades (Deccan) Secunderabad; **P. S. Rao,** Deputy Development Officer (Automobiles), Ministry of Commerce and Industry, Government of India, New Delhi; **N. R. Guruswamy,** treasurer, T.V.S. Workers' Union, Madurai; **J. G. Masilamani,** engineer-in-charge, India Radiators Ltd., Madras; **J. S. Murdia,** chief development engineer, National Engineering Industries Ltd., Jaipur.

Indian Automobile Ancillary Productivity Team recently visited SAE Headquarters. Organized by the National Productivity Council of India, the group is spending six weeks in the U. S. and one week in West Germany observing important productivity factors.

Escorting the group was Victor Kovanich, Jr. (far right), Industrial Training and Technical Aids Division, International Cooperation Administration. John J. Masilamani, Engineer in Charge, India Radiators Ltd. (rear — third from the left) is an SAE member.

Top Latin American Engineers To Talk at SAE's Pan American Day

SAE's PAN AMERICAN DAY—Thursday, January 11 at Cobo Hall in Detroit—is being programmed to deal with problems experienced by Latin American engineers and by U.S. engineers in Latin America.

Scheduled as an all-day feature of the 1962 SAE Automotive Engineering Congress, this 1962 "Special" has already scheduled six of the eight or nine papers planned. . . . Besides, an available-on-the-spot publication will be issued, containing all of the papers presented throughout PAN AMERICAN DAY . . . supplemented by an original background article titled "Automotive Engineering in Latin America" by Joseph K. Van Denburg, Jr., editor of McGraw-Hill's "Automobile International."

Already scheduled speakers who will come from Latin America include:

CARL A. OLSON, Jr., chief engineer, Industrias Kaiser Argentina, Santa Isabel, Argentina

BEN J. SMITH, chief engineer, Ford Motor Argentina, S.A., Buenos Aires, Argentina

ALEX A. CUNNINGHAM, works manager, General Motors of Brazil

Olson is expected to emphasize standardization problems currently facing international producers in South America. He will also touch on vendor development from an engineering standpoint and the need for training to answer quality problems.

Product engineering from a South American viewpoint will be Smith's theme. Cunningham's presentation is titled, "High Speed Nationalization of the Automotive Industry in Brazil."

With Brazil currently in the news headlines, particular interest will attach to this paper—which will discuss the future for automotive engineering and production as well as the developments which have already taken place.

Dr. Keith T. Glennon, president, Case Institute of Technology, and former director of the National Aeronautics and Space Administration, will make the Pan American Day keynote address on "Pan American Engineering Education." Recently returned from an extensive study of facilities, practices and potentials in education in both South America and Mexico, Dr. Glennon will report his findings and observations.

Speaker at the luncheon scheduled for the middle of Pan American Day will be the Honorable Hickman Price, Jr., Assistant Secretary of Commerce. Price has had years of experience in Latin American automotive work and will bring comments and conclusions based on his personal knowledge and experiences.

To Speak in January

BEN J. SMITH (left) and ALEX A. CUNNINGHAM (right) are among the featured speakers scheduled for SAE's Pan American Day at Cobo Hall next January 11. Smith is chief engineer, Ford Motor Argentina, S. A.; Cunningham, works manager, General Motors of Brazil. Both will deal with automo-.ive engineering problems of South America.

Keep SAE Young, Kucher Urges At Regional Section Officer Conference

SAE PRESIDENT ANDREW A. KUCHER urged West Coast Section Governing Board members to keep the Society young by catering to the young engineers and the engineering students. These men are valuable to the SAE of the future, and it is the Sections which can do most to make SAE attractive to them, Kucher added.

Representatives of seven West Coast Sections and Groups attended the Regional Section Officer Conference held in conjunction with the SAE National West Coast meeting in Portland, Ore., last August. In his address, Kucher also emphasized the growing international aspects of SAE activity and highlighted his recent visit to sister technical societies in Europe in company with SAE General Manager Joseph Gilbert.

Art Dillinger, Area Coordinator for the Northwest Sections, presided at the luncheon meeting, as general chairman of the National West Coast Meeting. Included among the special guests were Kucher; W. F. Ford, Sections Board past-chairman; I. M. Harlow, Area Coordinator for the SAE California Sections, Salt Lake, and Hawaii, S. E. Ellerbe, general chairman, 1962 National West Coast Meeting; and SAE General Manager Joseph Gilbert.

The emphasis on youth was continued by Harlow, who discussed Southern California Section's Mac Short Award, and its program of individual contacts with recent graduates in the area to assure them of welcome as SAE members. Individual Governing Board members are given a group of graduates to contact, he explained, noting that a similar program is followed by Northern California Section Governing Board members. Speaking of the importance of close contact between Sections and the Student Branches in their areas, Harlow stressed the value of bringing Faculty Advisors and Student officers to Section Governing Board meetings, and of senior members of the Society attending Student Branch meetings as often as possible.

Increasing student interest was reported by Spokane-Intermountain Section Chairman Hube Randall, who mentioned Gonzaga University, Washington State University, and the University of Idaho. He noted particulary the close relationship of Faculty Advisors to Student Branches, pointing

Section Officers Conference

. . . continued from preceding page

out that the Student Branches reflect the interest of their Faculty Advisors.

Reporting for the Northwest Section, Chairman Wally Brown felt that Student Branches would benefit from more moral support given to Student officers and Faculty Advisors. He stated that Father and Son (and Daughter) meetings have proved very successful.

Don McGuire, treasurer of the Oregon Section, said that "Boys' Day" meetings have been exceptionally successful. He felt that Sections should develop engineering interests of grammar and high school students so that they may plan ahead for engineering courses in college. The cordial relationship between the Section and the Student Branch at Oregon State University was emphasized by Section Chairman Fred Fulton. He spoke of frequent Section visits to the school, Student Branch visits to Section meetings, and excellent cooperation from Faculty Advisor Bill Paul, which had all added to the development of the existing close relationship.

The Salt Lake Group, according to Chairman Lionel Wildey, is concerned about a number of missile firms that are moving into the area, providing a challenge to attract their engineers as members. He asked assistance in providing programs of particular interest to them. The Group, he said, has difficulty in securing speakers from any distance because of the relatively small attendance at meetings.

The matter of meeting attendance was approached from another angle by Harlow, who mentioned that the Northern California Section experienced difficulty in getting accurate count upon which to make arrangements with the restaurant at which meetings are held so as to come reasonably close to a guarantee. Wildey asked the Society's attitude toward meetings with other organizations as a step toward alleviating uncertain attendance. Consensus has been that it may be desirable to have a few meetings held jointly with local Sections of other Societies, but that SAE Sections and Groups should limit the number of joint meetings and not rely upon them for attendance.

It was pointed out that it is not necessary in many instances to guarantee a speaker a large attendance, but it is always well to indicate number and technical competence of the anticipated audience in issuing an invitation to a prospective speaker.

SAE Visitors

DISTINGUISHED GUESTS at SAE Headquarters recently were Kenneth Platt, secretary, Institution of Mechanical Engineers, London (right), and Robert Millson, editor of Proceedings of the Institution (left).

8-Paper Instrumentation Session at Houston, Nov. 8

AN eight-paper instrumentation and research techniques session at the SAE National Fuels & Lubricants Meeting Nov. 8 begins a ground swell of new interest in instrumentation among SAE members. Always represented by a paper or two at most SAE meetings, the instrumentation and research techniques subject is currently getting top billing at two SAE events.

The November 8 session at Houston is devoted exclusively to fuels and lubricants instrumentation and research techniques. But the day-long "Experimental Engineers' Workshop" at the 1962 SAE Automotive Engineering Congress at Cobo Hall next January 10 (see p. 110, OCTOBER SAE JOURNAL) will range over much wider areas. Nine papers are already scheduled for this January session.

The F&L instrumentation session at Houston on November 8 is being chairmanned by D. W. Wing, Schlumberger Well Surveying Corp., who is currently chairman of the SAE Texas Gulf Coast Section. At the January session, Chevrolet's N. E. Farley will preside.

SAE National Meetings

November 8–10
Fuels and Lubricants
Shamrock Hotel, Houston, Texas

1962

January 8–12
Automotive Engineering Congress and Eposition
Cobo Hall, Detroit, Mich.

March 12–16
Automobile Week
(combined National Automobile and Production Meetings)
Sheraton-Cadillac, Detroit, Mich.

April 3–6
Aeronautic
(including production forum)
Hotel Commodore, New York, N. Y.

June 11–15
Summer
Chalfonte-Haddon Hall, Atlantic City, N. J.

August 13–16
National West Coast
Biltmore Hotel, Los Angeles, Calif.

September 10–13
Farm, Construction, and Industrial Machinery
(including production forum and engineering display)
Milwaukee Auditorium, Milwaukee, Wis.

October 8–12
Aeronautic and Space Engineering and Manufacturing
(including manufacturing forum and engineering display)
The Ambassador, Los Angeles, Calif.

October 29–November 2
Combined National Fuels and Lubricants; Powerplant and Transportation Meetings
Bellevue Strafford, Philadelphia, Pa.

NUMBER

1

Digest-listing of NEW and REVISED SAE Reports

Included are aerospace and ground vehicle standards, recommended practices, information reports, and materials specifications.

THIS is the first in a continuing series of monthly digests of new and revised SAE technical committee reports. Covered are those approved by the four ground and aerospace Councils of SAE Technical Board in August and September. Next month's list will include reports approved in October.

Aerospace Reports

NEW: **SPARK PLUGS, AIRCRAFT ENGINE (AS 28)** — Establishes essential minimum safe performance standards for shielded and unshielded spark plugs used in reciprocating engines. 14mm and 18mm types are covered. (Ignition Research Committee)

NEW: **TACHOMETER GENERATOR ENVELOPES (AIR 82)** — Dimensions installation clearance envelopes for tachometer generators. Applicable to envelopes for 4-pole and 2-pole tachometer generators using type XV-A and XV-B drives, respectively, at engine accessory pad. (Committee A-4, Aircraft Instruments)

REVISED: **CARGO COMPARTMENT FIRE DETENTION INSTRUMENTS (AS 400A)** — Sets forth essential minimum performance requirements for cargo compartment fire detection instruments used on *reciprocating-powered transports*. Covers three basic instrument types. (Committee A-4, Aircraft Instruments)

NEW: **CARGO COMPARTMENT FIRE DETECTION INSTRUMENTS (AS 446)** — Establishes essential minimum safe performance standards for cargo compartment fire detector instruments used on *turbine-powered subsonic transports*. Covers three basic types of fire detector instrument. (Committee A-4, Aircraft Instruments)

NEW: **TERMINAL, TAPER PIN, DESIGN AND APPLICATION (ARP 592)** — Is a guide on use of taper pins in taper pin terminal blocks, multi-contact electric connectors, and components designed to accept taper pins. The scope states that taper pins are intended to facilitate termination of a wire and are not for use as a quick-disconnect device. (Committee A-2, Aerospace Electrical Equipment)

NEW: **PROCEDURE AND METHOD FOR CONDUCTING TEST OF HYDRAULIC COMPONENTS IN CONTAMINATION CONTROLLED SYSTEM (ARP 219)** — Recommends procedure and method of conducting contamination control tests on aircraft and missile hydraulic systems and pumps so comparative results can be obtained. Three component classes are covered. (Committee A-6, Aerospace Hydraulic and Pneumatic Systems and Equipment)

NEW: **AEROSPACE HYDRAULIC AND PNEUMATIC SPECIFICATIONS AND STANDARDS (AIR 737)** — Current Military Standards and SAE Standards relating to hydraulics and pneumatics are listed. (Committee A-6 Aerospace Hydraulic and Pneumatic Systems and Equipment)

NEW: **TECHNICAL DATA REQUIREMENTS FOR SUPPORT EQUIPMENT (ARP 709)** — Provides a standard method of submitting technical requirement data to vendors. The format is flexible enough to encompass variations in data requirements of different branches of the Military Services. (Committee GSE-1, Military Support Equipment)

NEW: **NOMENCLATURE GUIDE FOR PROPULSION SYSTEM TOOLS AND EQUIPMENT (ARP 480)** — Is a guide for selecting drawing titles for tools and associated equipment used in the manufacture, installation and maintenance of propulsion systems. It is not intended for propulsion system parts. (Committee EG-1, Aerospace Propulsion Systems Support Equipment)

REVISED: **CONTROL LEVER CONNECTIONS — 60° V SERRATIONS (ARP 260)** — Two notes have been deleted to eliminate double dimensioning. They pertain to spiral angles and radial centerline of teeth. (Committee E-21, General Standards for Aircraft Engines)

NEW: **GAS TURBINE ENGINE POWER TAKE-OFF PAD REQUIREMENTS (AIR 67)** — Rating requirements of auxiliary power take-off pads for pre-turbine type engines as applied to helicopters are given. (Joint E-21/S-2 Helicopter Powerplant Subcommittee)

Aerospace Material Specifications

REVISED: **SILICON RUBBER, 1000 psi (55–65) (AMS 3346A)** — Revision affects minimum elongation value. (AMS Division)

REVISED: **STEEL CASTINGS, INVESTMENT, CORROSION AND HEAT RESISTANT, 19Cr-12Ni-((Cb+Ta) (AMS 5362D)** — Composition Section has been changed. (AMS Division)

REVISED: **STUDS, STEEL, LOW ALLOY HEAT RESISTANT, Normalized and Tempered, Roll Threaded (AMS 7458A)** — Structure Section has changed. (AMS Division)

Ground Vehicle Reports

REVISED: **SAE SEATING MANUAL** — A greatly expanded version of the 1955 edition, it gives the latest results of research and development on materials, testing, components, and manufacturing methods. Available as Handbook Supplement 135 only. (Body Engineering Committee)

NEW: **LOADING ABILITY TEST CODE-SCRAPERS** — Sets forth a procedure for measuring the loading-ability of a scraper. Recognizing the variables involved, this code is sufficiently general to cover any specified set of operating conditions and is applicable to all independent or combination construction and industrial vehicles designed to scraper-load and transport materials. Scheduled for 1963 SAE Handbook. (Construction and Industrial Machinery Technical Committee)

REVISED: **COMMERCIAL MOTOR VEHICLE NOMENCLATURE** — An illustration showing vehicle types based on axle arrangements has been added and minor changes made in certain definitions. This report will appear in the 1963 SAE Handbook. (Truck and Bus Technical Committee)

SAE's CEP NEWS

COOPERATIVE ENGINEERING PROGRAM

1000th AMS—A New Landmark for SAE

ISSUANCE of the 1000th SAE Aerospace Materials Specification brought praise from SAE President A. A. Kucher who recently commended the 72-man AMS Division on "unprecedented contributions made to U. S. metallurgical practices." He added: "The importance of this work is evidenced by the fact that 700,000 documents are sold annually."

At a recent Minneapolis meeting where the Kucher letter was read, AMS Division Chairman **N. E. Promisel** responded by pointing out that "AMSs are the most widely used documents of their kind in the world. Their board use stems from the fact that they are self-contained and their use *not* dependent on the referencing of other documents." It was further noted by Division members that in one extreme case a non-SAE document referenced some 1000 other specifications.

The AMS Division is made up of six Commodity and two Editorial Committees. The Commodity Committees (shown below) meet jointly for five days semi-annually while the Editorial Consultants Committee and Editorial Committee meet whenever a group of documents are ready for publication.

N. E. PROMISEL, chairman, AMS Division.

W. C. SCHULTE, vice-chairman, AMS Division.

D. E. MANNING, chairman, AMS Editorial Consultants Committee and AMS Editorial Committee.

COMMITTEE B—FINISHES, PROCESSES AND FLUIDS—Shown are F. T. Main, Jr. (left) secretary, and R. C. Kopituk, chairman.

COMMITTEE C—NON-METALLICS (ELASTOMERS-POLYMERS)—R. E. Pelzel (left), secretary, and R. R. Cutteridge, chairman.

COMMITTEE D — NONFERROUS ALLOYS — F. B. Yarborough (left), secretary, and G. F. Kappelt, chairman.

COMMITTEE E — CARBON AND LOW ALLOY STEELS AND SPECIALTY STEELS AND ALLOYS — H. B. Fernald (left), secretary, and W. C. Schulte, chairman.

COMMITTEE F — CORROSION AND HEAT RESISTANT ALLOYS — J. C. Mertz (left), chairman, and R. M. Frost, secretary.

COMMITTEE G — REFRACTORY MATERIALS — C. D. Dolch (left), secretary, and D. K. Hanink, chairman.

Better Coordination Aim of 3 New SAE Materials Groups

THREE new communication channels, in the form of liaison committees, have been created to improve and speed an exchange of information between major SAE ground and aerospace materials groups. This will mean better coordination of specification-writing in the Aerospace Materials Division of the Aerospace Council and in committees of the General Materials Council of the Technical Board.

H. B. Fernald, Jr., heads the AMS/Iron and Steel Technical Liaison Committee. Working with him are **G. D. Dolch, A. F. Jones,** and **W. C. Schulte.**

The AMS/Nonferrous Metals Liaison Committee is being led by **D. K. Hanink.** Other members include **J. C. Mertz** and **W. C. Schulte.**

N. B. Miller chairs the AMS/Nonmetallic Materials Liaison Committee which will keep posted on the work of the SAE-ASTM Technical Committee on Automotive Rubber. Other members include **J. C. Mertz** and **R. C. Pocock.**

H. B. FERNALD

D. K. HANINK

N. B. MILLER

6 Men Honored by AMS Division

HONORARY MEMBERSHIPS to the AMS Division were conferred upon B. Clements (left), L. D. Bonham, A. W. F. Green, J. B. Johnson, C. M. Miller, and P. P. Moxley by Chairman N. E. Promisel (right). These men were cited for "their discretion in resolving conflicts and ability to lead fellow committeemen in Division work."

PLAQUES FOR OUTSTANDING SERVICE are presented by SAE President A. A. Kucher to H. S. Brown (left), general chairman of the Meeting, and M. L. Frey, general chairman of the Production Forum Planning Committee. W. F. Wendt, Dean of Engineering at the University of Wisconsin (foreground) was toastmaster at the Awards Luncheon.

Versatile earthmover *highlights*

SAE Heavy Duty Vehicle Meeting in Milwaukee

A RADICALLY NEW EARTHMOVING MACHINE can be used as a bulldozer, scraper, tractor, troop carrier, and amphibious vehicle, engineers attending SAE's Heavy Duty Vehicle Meeting in Milwaukee were told.

Called the Universal Engineer Crawler Tractor, this light-weight, multipurpose vehicle was designed by the U. S. Army Engineer Research and Development Laboratories to replace conventional, single-purpose vehicles that have been used by combat engineer units.

The new vehicle features a hydropneumatic suspension system which provides springing, damping, and automatic leveling. The driver can control vehicle height and tilt when the suspension is in a rigid condition.

The Universal Tractor takes the form of a rectangular box, minus the top and one end. The bowl is at one end and the power train at the other, separated by a conventional "ejector." An apron closes the open end of the box.

The first prototype vehicle weighs 20,000 lb empty and 40,000 lb loaded. It has an Ordnance type wheel track and a top speed of 30 mph.

Faster tractors coming

Faster tractors which are easier to operate are being developed for the farmer. One large farm equipment manufacturer has developed a large four-wheel-drive tractor that is said to do three times the work of a conventional two-wheel-drive tractor on farms larger than 1000 acres.

This new tractor has a steering selector which enables the operator to use front or rear wheel steering, or four-wheel steering. Driven by a 375-hp engine, the tractor's speed is about twice that of a similar crawler tractor in the field.

Designers predict airborne farm equipment

In a few decades farm implements will be airborne, the seas will be farmed, and farmers will be able to relax in comfort while watching, via television, remotely-controlled, automatic farm equipment cultivate crops miles away. That's what three industrial designers predicted at the SAE Heavy Duty Vehicle Meeting in Milwaukee.

They said that radically new techniques and machines will have to be developed to feed the rapidly growing world population. The tractors and implements of today will soon be obsolete as new designs leave the drawing boards.

They cited the ground-effect vehicle and vertical-lift aircraft as certain to excite the imagination of the farm implement manufacturer.

Also, super-light materials used in conjunction with radically new power sources will make still undreamed-of-machines a reality. These machines will utilize nuclear, electronic, fuel cell, or turbine power, or perhaps make use of some new source of power unknown today.

Predicts car phones will jump

The average motorist will probably have a telephone in the glove compartment of his car by 1970. And it won't be very long before cars will be driven automatically along electronic highways at 150 mph, a leading electronics engineer predicted at the Meeting.

There are three areas — guidance and control, safety, and communications — which appear unusually attractive for application of electronics to vehicles 10–20 years from now. He predicted "futuristic electronic highways" which would result in automated vehicles designed to serve as mobile offices in intercity travel. Automobile telephones could be expected to increase from 18,000 today to five million in 10 years.

Electronics could be used to guide unmanned tractors across farm field

ELMER A. SPERRY AWARD RECIPIENT R. G. LeTourneau thanks Sperry Award board for the honor.

The Sperry Award is given for a distinguished engineering contribution which, through application proved in actual service, has advanced the art of transportation whether by land, sea, or air. LeTourneau received the award for his part in developing high-speed automatic earthmoving equipment.

The Elmer A. Sperry Award is presented under the joint sponsorship of the American Society of Mechanical Engineers, American Institute of Electrical Engineers, Society of Automotive Engineers, The Society of Naval Architect and Marine Engineers, and the Institute of the Aerospace Sciences.

and to bring raw materials automatically from the mines. Fully automated earthmovers or road graders could be expected to take their place in the construction and maintenance of future roads.

Computer helps design engine controls

An analog computer being used to simulate a gas turbine engine at the University of Michigan is proving helpful in designing controls for the engine.

The computer-simulator consists of conventional analog components such as summing amplifiers, integrators, coefficient potentiometers, multipliers, and function generators of one and two variables. Each engine variable is represented by a corresponding d-c voltage in the computer.

The computer is regarded as a working model of the gas turbine engine being simulated. The analog voltages produced by the computer correspond to the output variables of the engine, such as output shaft speed, torque, various temperatures, pressures, air flow rates, and such.

When input voltages, corresponding to input variables to the engine (such as fuel flow, load torque, ambient pressure and temperature) are varied, the engine simulator behaves just as an actual engine and the variables are caused to vary in the correct manner.

This simulation-by-computer provides the control designer with a test

ELMER A. SPERRY AWARD is accepted for The Firestone Tire & Rubber Co. by J. J. Robson (left), director of tire development and engineering for Firestone. R. P. Trowbridge director, engineering standards section, GMC, who is SAE's representative on the Sperry Award board makes the presentation.

Firestone received the award for its part in pioneering the giant size, heavy-duty tires which made feasible the operation of large capacity, high speed, earthmoving equipment.

R. G. LeTourneau (seated), other Sperry Award recipient, watches presentation.

1.

2.

engine which is much less expensive and more flexible than an actual engine. It cannot be damaged by tests and it may be readily connected to another analog computer-simulator of the control system itself. Thus a simulated engine with controls may be used to predict how an actual engine and control combination would work. Debugging can be accomplished before the actual equipment is built.

New family of small engines

A new family of small engines for the armed services is being developed by the Army Corps of Engineers and Continental Motors. The new family consists of six air-cooled engines ranging in size from ½–20 hp. The engines will be used to drive such military equipment as electric generators, air compressors, air conditioners, water and gasoline pumps.

The six engines will replace approximately 78 different makes and models used since World War II. Parts will be reduced from 23,000 for the 78 engines to about 800 for the new family.

Duplex tire gives greater mobility

Trucks using single, wide tires on each wheel instead of conventional dual tires have been found to be more mobile in sand and soft earth and to give less problems due to heat.

In a test of 32 trucks over desert terrain, none of the trucks equipped with single tires was struck in the sand or had a tire failure; whereas all of the dual-tired trucks became bogged down at least once, and on the average had one-and-a-half tire failures per truck.

In the cane fields of Hawaii, single, wide, Duplex tires proved to have superior mobility over dual tires; and, at the same time, they cleaned themselves of mud and rocks. (Dual tires require devices to dislodge mud and rocks which collect between tires.)

Logging trucks, too, ride much better with single, wide tires than they do with dual tires. They seem able to negotiate soft areas better, and have better brake performance because the brake drums are exposed to cooling air.

Push-button brakes coming?

Soon drivers may be able to apply parking brakes by merely pushing a button. The button could actuate a valve controlling an air or vacuum cylinder which furnishes the power for applying the brakes. Once applied, the mechanism could be locked and manually released as desired. Or, to have a "fail safe" system, the mechanism could be reversed so that the brake is applied with a stiff spring. The force of the spring would be overcome by a power cylinder controlled by the driver.

Propeller-shaft braking, now used only for parking, may possibly be adopted for emergency braking of heavy vehicles. It may be possible to bring trucks to emergency stops from speeds as high as 60 mph. At present, this isn't possible because during braking from moderate or high speeds, the components of this type of brake quickly heat to a temperature at which the drum melts and the organic brake lining disintegrates. However, with improvements in drum materials and the addition of improved inorganic materials in brake linings, parking brakes could be used for emergency braking.

16% of defense budget for missiles

About 6.8 billion dollars per year or 16% of the total defense budget is being spent on the development and production of U. S. missiles. That's what Edwin F. Sweetser, director of guided missiles, Office of Director of Defense Research and Engineering, Office of the Secretary of Defense told SAE'rs attending an evening session at the SAE Heavy Duty Vehicle Meeting. This compares with 58 million dollars spent on guided missiles in 1947, Sweetser said.

However, only about one-third of the 31 major guided missile projects

5.

6.

3.

4.

1. **SAE PRESIDENT** A. A. Kucher (left) congratulates R. A. Dimberg for fine job done in helping to organize and in promoting the SAE Heavy Duty Vehicle Meeting. Dimberg was chairman of attendance promotion. Attendance at 4000 was approximately 1000 ahead of the previous year.

2. **TRUCK AND BUS ACTIVITY COMMITTEE CHAIRMAN** R. R. Noble (left) meets with J. W. Mohr, chairman, SAE Milwaukee Section, before Awards Luncheon.

3. **ACTIVITY COMMITTEE CHAIRMAN** (l-r) A. W. Neumann (Transportation and Maintenance), W. F. Shurts (Farm, Construction and Industrial Machinery), and C. E. Habermann (Powerplant) prepare to attend Awards Luncheon.

4. **PRODUCTION FORUM SPONSOR** William S. Grede (right) receives outstanding service award from SAE President A. A. Kucher.

5. **DESCRIBING U. S. MISSILE PROGRAM** to SAE members was Edwin F. Sweetser, Director of Guided Missiles, Office of Director of Defense Research and Engineering, Office of the Secretary of Defense. Sweetser told how our missile program has grown — what the country is now getting for 6 billion dollars invested in the program — the projects, research, and developments aimed to further our world position. Sweetser brought along color films of actual missile operational trials to complement talk.

6. **FATHER AND SON** — Ernie (left) and Bob Panthofer check program for location of missile session. Bob came to see the color films of missile firings. Ernie was chairman of ticket sales at the meeting.

started in the U. S. since 1947 have become operational. The others have been canceled or replaced by new projects, Sweetser revealed. But canceled projects don't necessarily represent a total loss, he said. "They add to the reservoir of the nation's missile technology and often contribute components and techniques of value in other related projects or technical fields." Sweetser revealed that the initial navigation system on the nuclear submarine Nautilus was an outgrowth of the canceled Navaho guided missile project.

Plant tours draw many SAE'rs

Plant tours to A. O. Smith Corp. and Waukesha Motor Co. held in conjunction with the meeting drew S. R. O. crowds.

At A. O. Smith members observed the automotive frame assembly line and automatic welding equipment in action. Heat-treatment and heavy-duty metal-working facilities were also keenly watched.

At Waukesha Motor members had the opportunity to follow every step in the manufacture of internal combustion engines from the receipt of materials to the shipping platforms. Flame-hardening of camshaft lobes and crankshaft journals, heat-treating procedures for various other engine parts, unit assembly areas and test rooms, sheet metal forming and fabrication, and assembly of complete engine-driven generator sets were all on the agenda.

Participants at SAE heavy duty vehicle meeting

For the first time, five major SAE activities — Farm, Construction and Industrial Machinery (W. F. Shurts, chairman), Powerplant (C. E. Habermann, chairman), Transportation and Maintenance (A. W. Neumann, chairman), Truck and Bus (R. R. Noble, chairman), and Production (K. O. Tech, chairman) — participated at the annual Milwaukee meeting.

Heading up the General Committee was H. S. Brown. William S. Grede was sponsor and M. L. Frey general chairman of the Production Forum Planning Committee. Attendance promotion was in the hands of chairman R. A. Dimberg. Reception arrangements were handled by chairman F. R. Kishline. B. W. Wadman was chairman in charge of publicity. Co-chairman for plant tours were R. G. Jensen and J. W. Gottwald. E. H. Panthofer chairmanned ticket sales. F. B. Esty was chairman in charge of special events. The engineering display was in the hands of chairman E. E. Bryant. Host to the SAE Heavy Duty Vehicle Meeting was SAE Milwaukee Section, J. W. Mohr, chairman.

The Heavy Duty Vehicle Engineering Display included over 80 exhibitors utilizing 130 booths to graphically illustrate the latest in powerplants, power transmission equipment, and other hardware of interest to designers and production men. Over 25,000 sq ft of floor space were utilized to house the display.

CIMTC-ITA LUNCHEON — The problems facing the industrial truck industry and the earthmoving industry were explored at length at a luncheon meeting in Milwaukee to determine the desirability of SAE expanding its standardization work into the industrial truck field.

Co-Chairman J. Johnson of the CIMTC and Fred Schuster of the Industrial Truck Association led the discussion at which the accomplishments of the CIMTC and its contributions to the engineers and companies in the earthmoving field were outlined in detail.

The ITA has been conducting a limited amount of standardization activity in its industry and some of its member companies have shown interest in pursuing this activity under the auspices of SAE.

RADIATORS — The first meeting of SAE's new Radiator Subcommittee in Milwaukee was devoted to a review of a number of existing SAE Standards in need of revision in addition to considering the development of a test code to better evaluate heat rejection, air flow, and cooling ability of radiators.

Dave Schafale, General Radiator, Inc., is chairing the Subcommittee.

REMOTE AND AUTOMATIC CONTROLS — The problems associated with remote control of earthmoving equipment designed to function in areas contaminated by radioactive fallout were considered at a meeting in Milwaukee of the CIMTC's new Subcommittee XIX — Remote and Automatic Controls.

Chairman James Graas, Dynex, Inc., led the subcommittee in outlining a program to establish uniform nomenclature in this area and standards that may be needed, in addition to the programming of technical papers exploring the advantages of various designs of equipment which thus far have been built for use by the military.

This subcommittee is functioning in a unique field inasmuch as such equipment is not in commercial use as yet.

SPARK ARRESTER SUBCOMMITTEE — The problems facing the railroad industry, U. S. Forest Service, and conservation departments of the various states in controlling fires resulting from exhaust spark emission of internal combustion engines were aired at an organizational meeting of the SAE's new Spark Arrester Subcommittee in Milwaukee.

Chairman Pete Burns of Ford's Tractor and Implement Division, reported that the subcommittee also planned to consider problems in controlling sparks emitted from engines used in farm tractors and power chain saws.

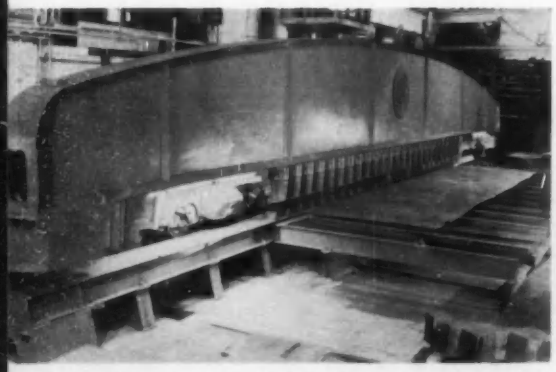
SAE presently has a standard used by the farm tractor industry which is in need of revision.

Scenes from the SAE Heavy Duty Vehicle Engineering Display

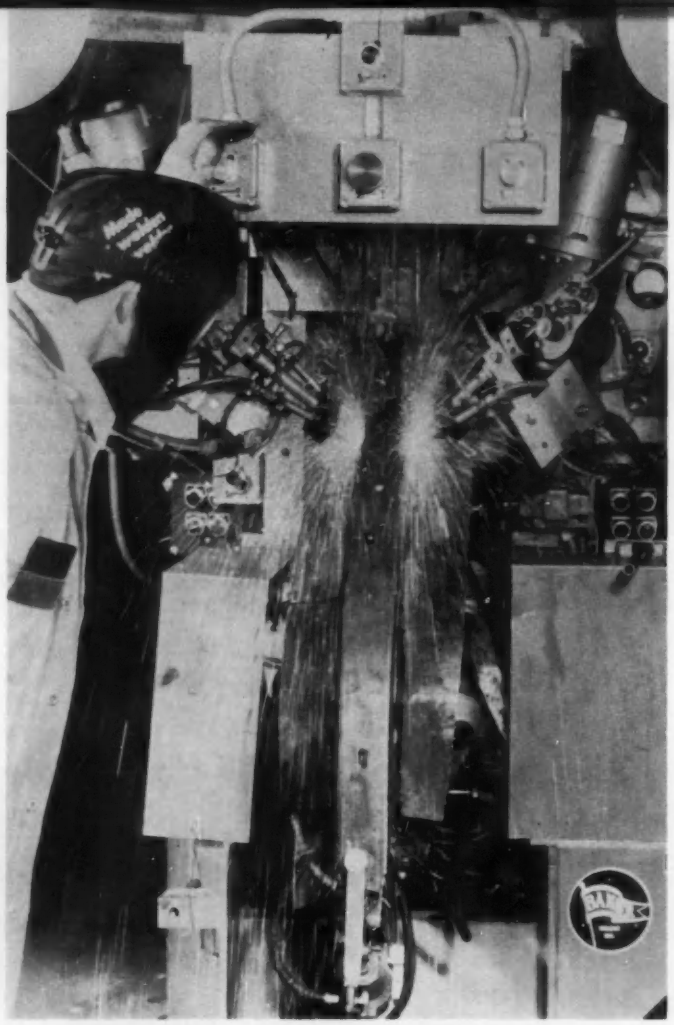
views from the

A. O. Smith tour

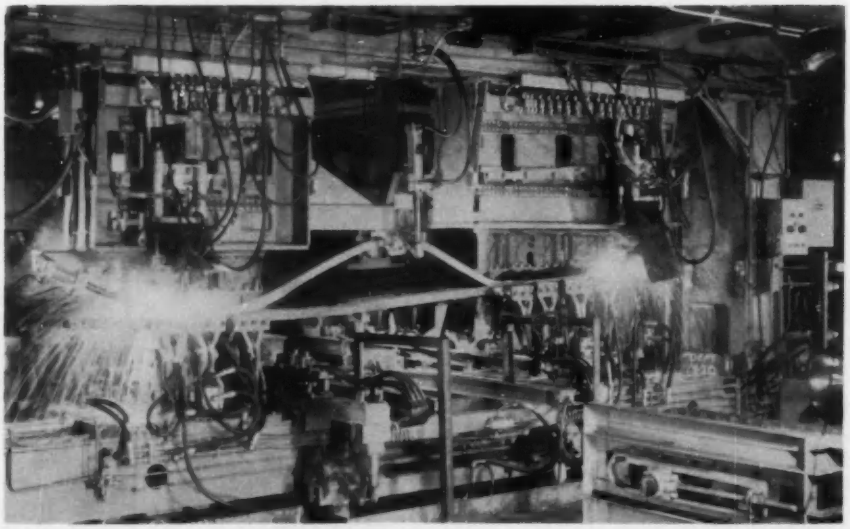
at SAE Heavy Duty Vehicle Meeting



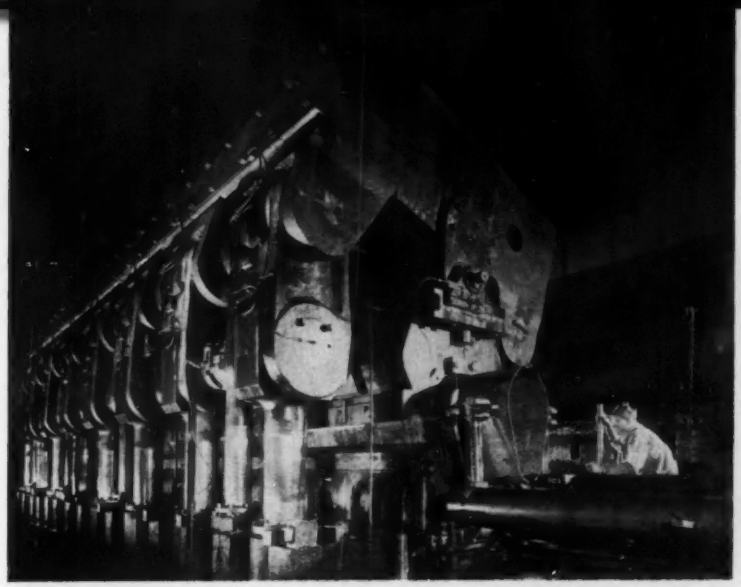
SHEAR PLANER will shear material up to 5/8 in. by 41 ft and can plane steel plate up to 3 in. by 41 ft.



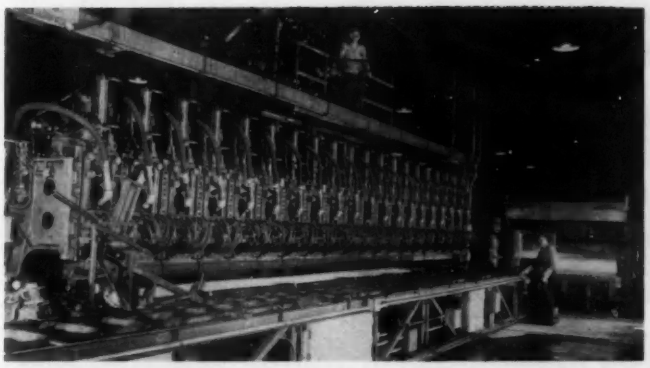
TWO C-OMATIC HEADS mounted for simultaneous welding of automotive front cross bar. Irregular shaped piece is rotated between the two heads. No tacking is required.



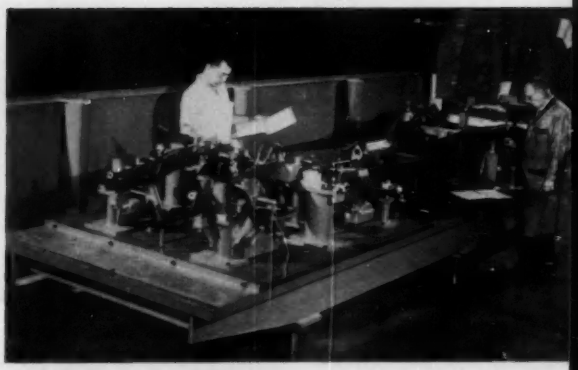
AUTOMATIC WELDING FIXTURE uses four C-Omatic welding heads which utilize carbon dioxide as inert gas for welding. Each of the four welding heads is capable of speeds up to 300 in. per min. The fixture is automatically loaded and unloaded. No tacking is required.



"PEARING" A TWO-TON 40-FT LENGTH OF STEEL in special machinery as part of the production of line pipe in diameters up to 36 in. This is one of the steps preparatory to closing the pipe so that a sound, secure weld can be made.

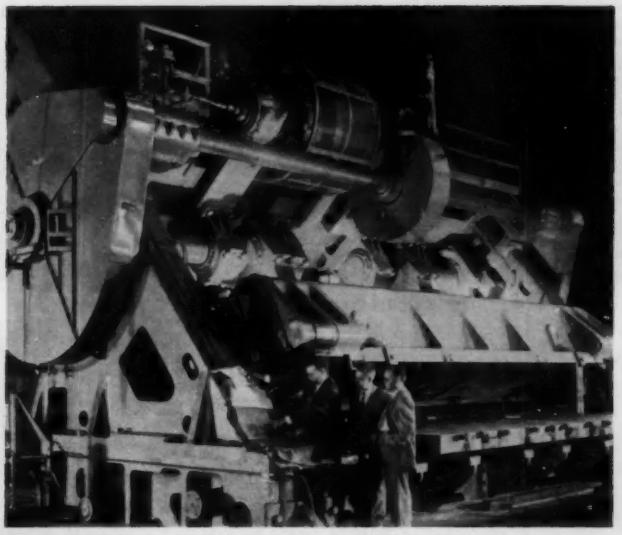


DIE-QUENCH MACHINE HARDENS CHANNELS TO 40 FT LONG — This special die-quench machine hardens channels up to 40 ft long and 18 in. deep in stock thicknesses up to ½ in., with or without contours.



QUALITY CONTROL ASSEMBLY on truck frame. Extensive use of gages and fixtures assure conformance to specifications.

4,000 TON PRESS forms truck and trailer rails up to 40 ft long and up to ⅝ in. thick. It also forms high strength steels up to 90,000 psi yield.



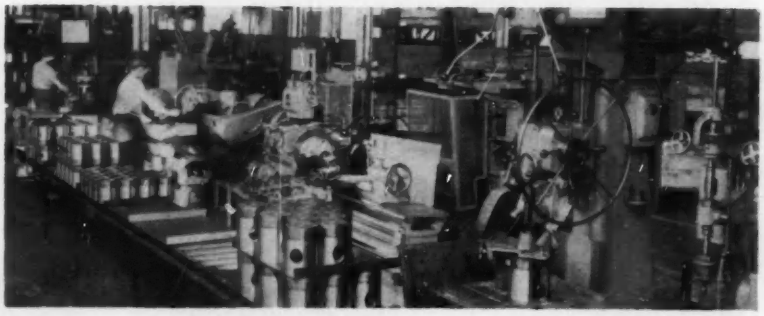
"KICK-UP" PRESS uses 800 tons pressure to edge-bend metal for passenger car and truck side rails.

views from the

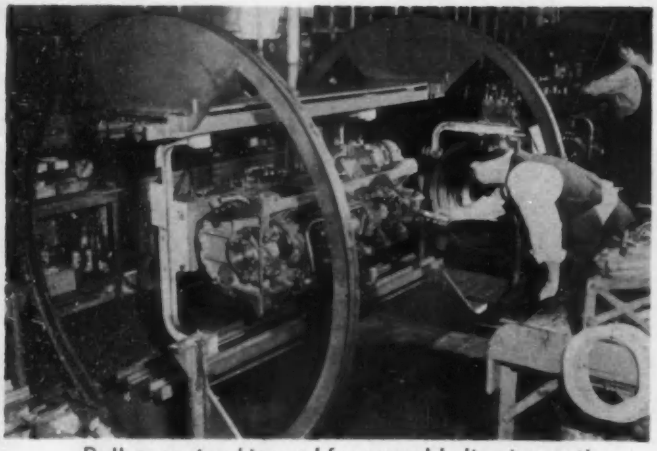
Waukesha Motor tour

at SAE Heavy Duty Vehicle Meeting

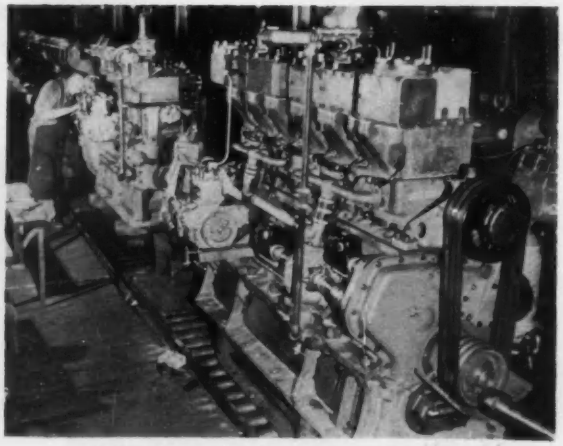
Overhead oiling on six-cylinder engines assembly line.



Piston machining line.

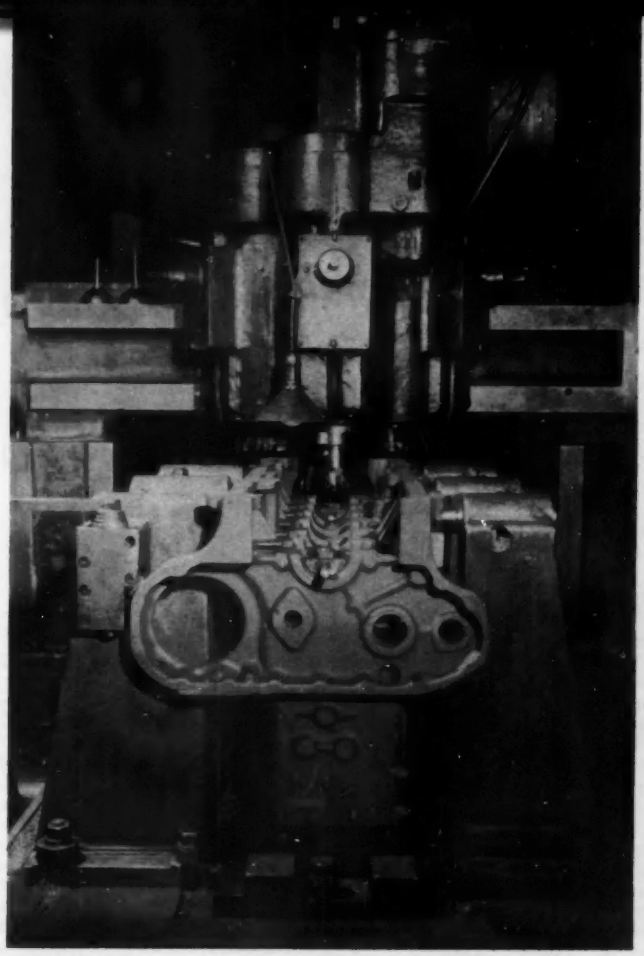


Roll-over stand is used for assembly line inspection.



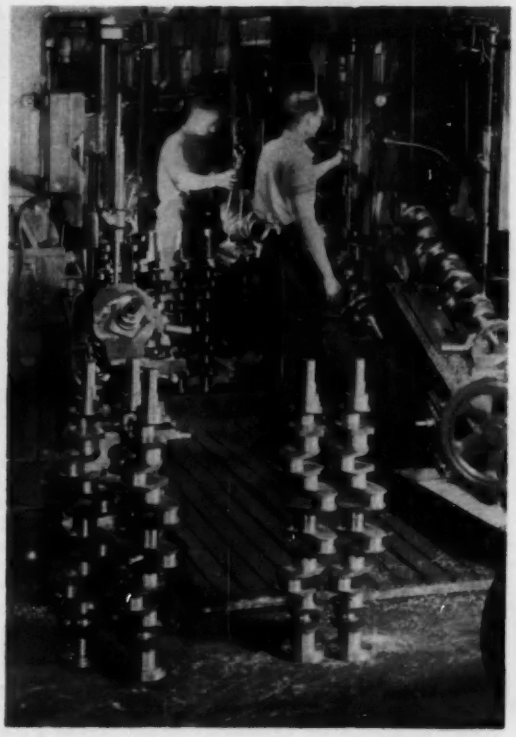
Large six-cylinder engines assembly line.

Small and medium engine testing



Milling seats for main bearing caps.

Oil channel drilling of crankshafts.



Milling four-cylinder crankcases.

Crankcase multiple-hole drilling and tapping.

Speaker James Moir and Hawaiian Section Chairman Harry Smith.

Rambling through

Rambling Through Governing

. . . . **ATLANTA SECTION** opened its 1961–62 year with revelations, by "Red" Vogt, of passenger car design weaknesses which have showed up via stock car racing. Vogt, now connected with Atlanta International Raceway, rode as a mechanic in old Mercer and Stutz racing cars back in the early '20s. . . . In October the Atlanta Section made a field trip to the Atlanta Airport. . . . **HAWAII SECTION** late in August heard James Moir, Honolulu distributor for GMC diesels and Peterbuilt Trucks, outline design problems in development of V-type heavy-duty diesel truck engines. He said that recent development efforts, have been devoted to considerations of lighter weight, shorter fan-to-flywheel length, lower initial cost, and true fuel economy. Previously, he pointed out, most design work had to be aimed at raising horsepower output, increasing service-life standards, and reducing routine as well as major maintenance expenses. Moir, who is manager of Moir Industries, Inc., exhibited for inspection at the meeting a late model Peterbuilt truck equipped with a late-model GM V-8 diesel engine. . . .

PLANT VISITS give promise of playing an even greater role in 1961–62 SAE Section activities than ever before. On the upswing for some years, this type of Section meeting has developed increasing values to those attending, as Sections have perfected their handling of these technical-information gatherings. Evidence of current widespread Section interest in plant visits runs through scores of early Section meeting programs and Governing Board plans. . . . **CLEVELAND SECTION** for example, held a powerplant activity tour of Cleveland Graphite Bronze, a Division of Clevite Corp., at which "spark pumps" were discussed. . . . **COLORADO SECTION** already has plans for a tour of the Air Academy in the spring. . . . and **DAYTON SECTION** visited Janitrol Aircraft Division at Columbus in the early Fall. . . . A family field trip to the United States Armory at Springfield, Mass. was enjoyed by **SOUTHERN NEW ENGLAND SECTION**, including a tour of the museum and a steak dinner. . . . **BUFFALO SECTION** visited the Bethlehem Steel plant. . . and several weeks later held a plant tour of Eastman-Kodak Co. . . .

Section Meetings

ATLANTA

November 6 . . . Eugene A. Bordinat, Jr., vice-president & director of styling, Ford Motor Co. "Automotive Styling." Yohannan's Restaurant, Lenox Square, Atlanta, Ga. Social Hour 6:30, dinner 7:00; meeting 8:00 p.m.

BALTIMORE

November 16 . . . Leonard G. Schneider, head, Lubricants Branch, U. S. Naval Engineering Experiment Station. "Ask the Engine about Series 3 Oils." Meeting place: Baltimore Engineers Club, 7 W. Mt. Vernon Place. Dinner 7:00; meeting 8:00 p.m.

BUFFALO

November 6 . . . Dr. Norman L. Barr, defense systems, division of General Motors Corp. "Bio-Chemical and Bio-Medical Studies Relative to Space Flight." Party House, 677 Beahan Rd., Rochester. Dinner 6:30, meeting 8:00 p.m.

CENTRAL ILLINOIS

November 20 . . . Dr. A. A. Kucher, SAE President. "European Engineers." Pere Marquette Hotel, Peoria, Ill. Dinner 6:30; meeting 7:45 p.m.

FORT WAYNE

November 8 . . . Verne Koppin, chief engineer, Creative Industries of Detroit. "The Evolution of Automotive Body." Hobby Ranch House. Dinner 6:30; meeting 8:00 p.m.

INDIANA

November 16 . . . Lloyd J. Wolf, assistant vice-president, Wolfwagon, St. Louis Car Co. "History & Development of the Wolfwagon." Continental Hotel, Indianapolis, Ind. Dinner 7:00; meeting 8:00 p.m.

METROPOLITAN

November 2 . . . Representatives from Mack Trucks, Inc., International Harvester Co., & White Motor Co. "Guaranteed Maintenance." Brass Rail Restaurant, Fifth Ave. between 43rd & 44th Sts., Manhattan. Social hour 5:30; dinner 6:30; meeting 7:45 p.m.

November 9 . . . Alfred E. Kunen, manager, plasma propulsion project, and Robert E. Supp, chief, electric advanced propulsion branch, director of aeromechanics, Republic Aviation Corp. "Plasma Engines." Meeting place: Republic Aviation Corp., Farmingdale, N. Y. Sponsored Cocktail hour 5:30; dinner 6:30; meeting 7:45 p.m.

MID-MICHIGAN

November 27 . . . Joseph E. Godfrey,

the Sections

Board Minutes . . .

The response to these tours has been large enough to necessitate limiting attendance to applicants and members of SAE. . . .

Available to **ONTARIO SECTION** members were tours through the plants of McKinnon Industries, Ltd., and Thompson Products, Ltd. . . . The total number of membership applications received, throughout the Sections, in June and July were higher than the same months last year. August, however showed a small decrease. . . . Perhaps the brisk autumn weather, combined with the stimulation of Section plant tours will show a return to the early summer membership upswing.

. . . . **NEW ENGLAND SECTION** Governing Board this year has 32 members. . . . "Get Acquainted Night" started **NORTHWEST SECTION** in action for the 1961–62 year — on September 6 at the Mountain Room of Sick's Ranier Brewing Co. Wives were invited — and many came. . . . And later in September a successful Northwest Section "Father-Son-Daughter Night" party toured the Great Northern Railroad Interbay Shops and Roundhouse. . . .

Sperry

CHICAGO SECTION Chairman Phil Sperry sent a personal letter of welcome to all new Chicago Section members early this fall. He told them about the character and timing of the Section's meetings — and encouraged participation in activities by the newcomers. "As you must know by now," he reminded them, "one's reward from membership in a technical organization is in direct proportion to his participation in the activities of that group." . . . Sperry speaks with the voice of experience: long before becoming Section Chairman, he had contributed as a member to the work of the Construction and Industrial Machinery Technical Committee and served as its chairman, to the work of Farm, Construction & Industrial Machinery Engineering Activity Committee — in addition to his earlier Section activities. . . .

TEXAS SECTION is looking far ahead to future uses of fuels. . . . Aircraft Vice-Chairman M. A. Atkins is considering "Outer Space Refueling" as a Texas meeting topic this year. . . . Section Secretary D. H. Norton reports that Texas Section Past Chairman are now getting "different" badges to wear at Section meetings — "so they can be recognized more readily." . . .

. . . . **OREGON SECTION** is continuing its practice of Friday noon luncheons. . . . **COLORADO SECTION** Governing Board feels the Section needs stimulation, Section Secretary G. M. Jones reports. Important specific action being contemplated is use of an active telephone committee to stimulate attendance at meetings. . . . **DAYTON SECTION** this year will charge guests $1 more than members for Section dinner meetings. . . .

works manager, Saginaw Steering Gear Division, G.M.C. "Production Activity." Bancroft Hotel, Saginaw, Mich. Dinner 6:30; meeting 8:00 p.m.

MILWAUKEE

November 3 . . . Ralph Lambrecht, chief engineer, boat section, marine engineering, Outboard Marine Corp. "A Brief History of Power Boat Racing Hull Development." Milwaukee Athletic Club. Dinner 6:30; meeting 8:00 p.m.

December 1 . . . Dimitri D. Kececioglu, director of reliability, Allis-Chalmers Mfg. Co. "Panorama of New Power Generation Developments," Milwaukee Athletic Club. Dinner 6:30; meeting 8:00 p.m.

PHILADELPHIA

November 8 . . . Prof. L. C. Lichty of Yale University. "Piston Engines in the Space Age." Engineers Club, 1317 Spruce Street, Philadelphia, Pa. Dinner 6:30; meeting 8:00 p.m.

PITTSBURGH

November 28 . . . John S. Wintringham, senior research advisor, Ethyl Corp. "Potential Passenger Car Powerplants." Pittsburgh, Pa. Dinner 6:30; meeting 8:00 p.m.

ROCKFORD-BELOIT

November 6 . . . Plant Tour, Highway Trailer Industries, Inc. Edgerton, Wisconsin. Dinner 6:30; meeting 7:45 p.m.

SOUTHERN NEW ENGLAND

November 30 . . . William Lewing, E. I. du Pont de Nemours Co., Inc. "Plastic Substitutes for Metals." Bradly Field, Terrace Dining Room, Windsor Locks, Conn. Dinner 6:45; meeting 8:00 p.m.

TWIN CITY

November 8 . . . Dr. Maz Bentele, chief scientist, Wright Aeronautical Division, Curtiss-Wright Corp. "The Wankel Engine." Hasty Tasty Restaurant, Hennepin & Lake St., Minneapolis. Dinner 7:00; meeting 8:00 p.m.

WICHITA

November 16 . . . Jack Prendergast, Ford Motor Co. "Light Cars." Innes Tea Room, Wichita, Kansas.

WILLIAMSPORT

November 13 . . . S. K. Hoffman, vice-president, North American Aviation Corp. "Rocket Engines." Williamsport Moose Auditorium, 33 E. 3rd St. Dinner 6:45; meeting 8:00 p.m.

SAE MEMBERS

Brennan

Hykes

Norton

Bryan

Abelson

J. H. FAMME has been appointed vice-president — general manager, General Dynamics/Convair. He has been associated with Convair for a number of years and assumes this position after a brief period as vice-president — operations. Previously he was manager of the Division's manufacturing development.

Famme is a past SAE Director, a past-chairman of the San Diego Section, and currently continues as a member of the Aerospacecraft Activity Committee of the SAE Engineering Activity Board and of the Aerospace Council of the SAE Technical Board.

JOHN E. BRENNAN, formerly a vice president of Chrysler Corp., has joined Federal-Mogul-Bower Bearings, Inc., as a vice president of the corp., and general manager of the International Division. He will assume responsibility for the company's present manufacturing operations outside the U.S., and will assist in the expansion of their international manufacturing program.

PAUL G. HYKES, former head of wheel engineering, has been appointed executive engineer — brakes at the Automotive Division of The Budd Co. He will direct a new engineering section designed to expand development and production of brakes and brake drums.

ROY C. NORTON, previously head of Budd's customer service, has been made executive engineer — wheels and will direct extension of wheel development.

JACK D. BRYAN has been named general manager of the newly created Speedostat Division of Perfect Circle Corp. In this position Bryan will supervise sales, engineering and manufacturing activities related to Speedostat, a vehicle speed regulating device developed a few years ago by Perfect Circle.

He has been general service manager for the firm's Engineering Division for the past six years.

RICHARD D. ABELSON has been named vice-president for manufacturing of the Textile Machinery Division of Saco-Lowell Shops, a subsidiary of Maremont Corp. Since 1946, when he joined the company as an industrial engineer, Abelson has been associated with Maremont and its various subsidiaries.

DONALD MacMILLAN, former service engineer with General Motors Corp., Overseas Operations, is now with White Motor Co. as project engineer — vehicle application. In his new position he will review all orders for trucks to be certain that model and components specified are the best possible combination for the job that the truck will be expected to do.

PAUL M. JENSEN has been made sales engineer at the John Boyko Engineering Co. He was previously assistant managing engineer, Central Engineering, Chrysler Corp.

Jensen has been active in SAE as a company representative from 1959 to 1961 and as symposium moderator at the National Meeting in Atlantic City in 1956.

PAUL G. HOFFMAN was one of six "pioneers of professional policing" — founders of the Traffic Institute of Northwestern University — honored at a reception and dinner on Oct. 14 on the occasion of the 25th Anniversary of the Institute. Hoffman — former president of Studebaker Corp. — is director of the United Nations Special Fund. The reception and dinner were held at the Pick-Congress Hotel in Chicago.

Ford Appointments

Richards

Pretz

Hopeman

MAJOR ORGANIZATIONAL REASSIGNMENTS have recently taken place in Ford Motor Co.'s engineering staff, along with the establishment of new Offices, it was announced by **V. G. RAVIOLO**, executive director.

JESSE W. RICHARDS has been appointed director of the newly established Technical Analysis Office. He was formerly executive engineer, advanced Ford and Mercury, Ford Product Engineering Office.

PHILIP H. PRETZ is now director, International Engineering Office, a new component of engineering staff. Pretz, an SAE past director, had been director of Testing Operations.

VICTOR HOPEMAN, formerly executive engineer, Testing Laboratories, has taken over as director of Testing Operations.

Succeeding Hopeman, is **ROBERT W. GAINES**, who was manager of Ford's Michigan Proving Ground Department. **GLENN F. DOYLE**, the former manager of the structure testing laboratory department at the Proving Ground, succeeds Gaines.

Working with Pretz in the International Engineering Office, is **H. A. BOLENSKI**, associate director. He had previously been chief engineer, Product Engineering Office. There have also been three executive engineering appointments made in the newly retitled international engineering department, of which **C. L. WATERHOUSE** remains manager.

F. W. BLOOM, executive engineer, European region, had been manager, product study, vehicles department.

L. E. BOYSEL, executive engineer, Latin American region, was formerly general product engineer, Metal Stamping Division.

P. H. KUHN, executive engineer, Commonwealth region, was previously chief Lincoln car engineer.

In the Engineering and Research Staff there have been new appointments, as follows:

A. C. BODEAU is executive engineer, product study technical service and systems engineering.

B. T. HOWES is executive engineer, product study vehicles, engines and components.

J. M. CHANDLER has been made manager of vehicles safety and exhaust department.

J. F. WHITE is manager of vehicle testing laboratory department.

R. P. ERNEST is assistant manager, product study vehicles.

The Transmission and Chassis Division of the company has had several personnel changes as well.

V. J. JANDASEK is now executive engineer responsible for automatic transmission engineering.

ROBERT W. SMITH is now executive engineer responsible for axle, standard transmission and steering gear engineering.

ROBERT W. STEVENSON has been made general manager, Transmission and Chassis Division.

JOHN W. GREER, now manager, production contact and resident engineering department, has switched jobs with **RICHARD A. ARMSTRONG**, now manager, experimental engineering department.

COLONEL HAROLD N. BROWNSON, formerly deputy commander of the Army Balistic Missile Agency in Alabama, is now assigned to Office — Chief of Ordnance, in Washington, D. C.

R. D. SLONNEGER, West Virginia University associate professor of mechanical engineering, returned to the campus after a nine week Ford Foundation sponsored program at the University of Michigan on the use of computers in engineering education. While there, he prepared and programmed problems for undergraduate engineers to solve on analog and digital computers.

GORDON J. KUIVANEN is now employed by the Engineering Research and Development Division of Motec Industries Inc., as Moline Automotive project engineer. He was formerly a senior research engineer with the General Motors Research Laboratories.

HARVEY S. FIRESTONE, JR., chairman and chief executive of the Firestone Tire and Rubber Co., sailed recently for France where he will preside at the dedication ceremony of the company's new tire plant in Bethune and inspect the synthetic rubber plant now under construction at Port Jerome.

During his stay in Europe, Firestone also plans to visit the company's plants in England, Spain, Portugal, Switzerland, Sweden and West Germany.

DR. ARTHUR W. LEWIS former superintendent of technology at the Tidewater Oil Co.'s Delaware refinery, has been named to an assignment at the company's home office in Los Angeles.

JOHN K. WOODBURN is now associated with Sifto Salt, Ltd., subsidiary of Dominion Tar & Chemical Co., Ltd. as municipal sales engineer. Prior to this appointment, Woodburn was product application engineer with the British American Oil Co.

JOHN C. HOLLIS, since Sept. 15, has been Director of Business Workshops with the Commerce and Industry Association of New York, at 99 Church St., New York 7.

Hollis will continue to serve as a consultant to SAE, where he had been scheduled to retire as manager of the Administrative Division next January. He had held this managerial post since 1944, had served as secretary to the SAE Finance Committee throughout the same period, and as secretary to the SAE Placement Committee since 1947.

Hollis

HAROLD NUTT has been elected chairman and chief executive of the Borg & Beck Division of Borg-Warner Corp. Nutt, a veteran automotive executive and president and general manager of Borg & Beck since 1955, joined the company in 1930 as director of engineering.

Previous to his association with Borg & Beck, Nutt performed in various capacities for Durant Motors, Premier Motor Co., Fairbanks Morse & Co., and B. F. Sturtevant Co. He is a graduate of Worcester Polytechnic Institute.

Shealor

Brown

Lutz

WALTER H. SHEALOR, assistant director — sales — International Division of the Timken Roller Bearing Co., has established his headquarters in Colmar, France. He serves as liaison on sales problems in the European area between the general office in France, and the sales office in Ohio. A veteran of World War II, Shealor has been with the Timken Co. since 1946.

The newly formed Engine Parts Division of Gould-National Batteries, Inc. has **THOMAS C. BROWN** as its general sales manager. He has held various sales executive positions during his association, since 1949, with the organization.

J. O. LUTZ has been named manager — sales engineering, Original Equipment Market and Industrial. Previous to his present appointment, Lutz was general sales manager of Wilkening Manufacturing Co.

Two SAE members have been reappointed to the Transportation and Communication Committee of the Chamber of Commerce of the United States for 1961–62. They are: **HARRY O. MATHEWS,** vice-president — transportation & distribution, Armour & Co.; and **LIGHT B. YOST,** director, highway & traffic safety section, distribution staff, General Motors Corp.

The committee studies major issues affecting the transportation and communication industry. It also studies legislation before Congress and recommends Chamber policies in this field.

JAMES L. BOMBERGER has become project engineer in the equipment design branch of Brown Engineering Co., Inc. His work will concern saturn launch equipment, erection towers, and pneumatic check-out and training equipment.

LEO KAPLAN has joined the Avco Corp., researchers and developers of missile nose cones, as senior engineer — logistics and test support.

CHARLES E. HEITMAN, JR., a vice president and member of Bendix Corp.'s administration committee, has been assigned new executive responsibilities for three of the corporation's companies: Cleveland Instrument, Micrometrical Mfg., and the Industrial Controls Section. He will continue to have jurisdiction over Bendix Products Division-automotive section, and Sheffield Corp. and its associated companies.

The three Divisions involved in the change have previously been directed by **LOUIS POLK,** a Bendix director, vice-president and group executive, and chairman of the board of directors of Sheffield Corp. He will continue to administer special assignments in the fields of automation, machine tool and other business developments.

EDWARD C. DUDLEY is now chief engineer for Rain-O-Mat Sprinklers, Inc. In this position he will work on research and development of new irrigation sprinklers and improved devices for automotive and hydraulic equipment.

Dudley was previously development engineer for Thompson-Ramo Wooldridge, Inc.

LEONARD H. MAPES, formerly export manager, Vickers, Inc., a division of Sperry Rand, Inc., has been appointed district manager, Vickers Products Corp., Zurich. He will direct sales and marketing of hydraulic products to European aviation industry.

M. G. BEKKER was U. S. National Secretary of the First International Conference on the Mechanics of Soil-Vehicle Systems held last June in Turino, Italy. He chaired the closing session of the Conference and delivered the closing address. Bekker, who is head of the Land Mobility Laboratory, GMC Defense System Division at Santa Barbara, Calif., reports that the various national secretaries have been authorized to draft the general terms of references of an "Association" which would continue an international activity for the advancement of soil-vehicle studies . . . and which will establish the date and place for the next International Conference. Preparations for the meeting of national secretaries from this country, Canada, England, France, Italy, Germany and other countries have already started with the cooperation of the U. S. Army Research Office.

LYLE WALSH, manager of Engineering Staff Activities of General Motors Corp. since 1945, retired at the end of August. He began his 35 years with GMC in 1926 at Oldsmobile, has been assistant to five vice-presidents, and secretary of GMC's Engineering Policy Group, and of the General Technical Committee. Walsh and his wife plan to live on Lake Charlevoix in Northern Michigan.

KEN BROOKER who had been serving as assistant to Walsh since 1955, has been named manager of Engineering Staff Activities. He has been with GMC since 1942, starting at Fisher Body and transferring to the engineering staff in 1947.

His former responsibilities were taken over by **TOM FISHER,** administrative engineer from the Proving Ground.

ARTHUR H. ZEITZ, JR., has been appointed chief automotive engineer — Gulf Coast Region Ethyl Corp. The Gulf Coast Region is newly established by Ethyl and is part of a realignment of sales department responsibilities.

Zeitz was assistant supervisor, technical service division, research and development laboratories, Ethyl Corp. before this appointment.

He is an active member of the Detroit Section and has served nationally on the Diesel Engine Test Code Subcommittee and as a Powerplant Activity member in 1960–61.

JOHN R. BURRELL, JR. has recently joined the Brunswick Corp., manufacturers of sporting, school and hospital equipment, as senior product designer for bowling alley equipment. Mr. Burrell previously worked for the Chrysler Corp. as a chassis design engineer.

JEAN F. DeCELLES is now general sales manager of P. Demers, Inc., in charge of reorganizing the sales promotion and territories in Quebec Province. He was formerly associated with United Auto Parts in Montreal.

DWIGHT J. BRIGGS who was a design checker for Ford Motor Co., has become a product designer for the Transmission & Axle Division of Rockwell Standard Corp.

WALTER A. WORON has been made public relations director for Renault, Inc., New York. Previously he was president, Walt Waron Associates.

LEW B. WOODALL is now associated with Azusa Transfer Co. as superintendent of maintenance. He was formerly superintendent of maintenance for Garibaldi Equipment Co. In his new position Woodall will write specifications and purchase equipment layout and supervise maintenance and rebuilding procedures.

He is also a consultant for Analysts, Inc., Oakland, Calif.

PAUL J. DURNING recent M.S. in mechanical engineering from the University of Illinois has accepted a position as research engineer in Producing Research, La Habra Laboratory, California Research Corp.

MELVIN F. DIELS development engineer with Aerojet-General Corp. is leaving to do graduate work in mechanical engineering at the University of Arizona.

ANDREW F. HAIDUCK is now vice president and general manager, Astronics Division, Lear, Inc. He was previously vice-president — manufacturing.

Changes at GMC Truck & Coach Division

Crockett

Flynn

Field

Labelle

Edwards

C. V. CROCKETT has been appointed as director of defense products and **H. O. FLYNN** as chief engineer of General Motors Corp., Truck & Coach Division. Flynn, formerly assistant chief engineer of Chevrolet, succeeds Crockett who served as chief engineer of GMC for six years before being named to the newly created defense products post. Crockett has been with GMC since 1924 and Flynn since 1932.

Both men are active members of SAE. Flynn has been a member of the Buffalo-Rochester Section Board of Governors and the SAE Transportation Engineering Formula Subcommittee on Truck Ability Prediction. He has also held offices in the Detroit Section Truck and Bus Activity and at present is a national committeeman of this activity. Crockett is a member of the Technical Board and a sponsor of the SAE Automotive council.

Other appointments in the GMC Truck and Coach Division are those of **R. E. FIELD** and **D. J. LaBELLE** as assistant chief engineers responsible for trucks and coaches, respectively. Prior to this appointment, Field served as truck engineer. LaBelle is transferred to the coach engineering operation after serving as assistant chief engineer for trucks. Both Field and LaBelle will report to H. O. Flynn.

In addition **W. W. EDWARDS** has been made truck service manager. He was previously technical service manager.

HARRY W. BURDETT, JR. has become manager of planning for American Machine & Foundry Co.'s government products group. Formerly with Reaction Motors Division of Thiokol Chemical Corp., he worked as project engineer on the rocket engine used in the first supersonic aircraft. Burdett has been a member of the SAE Powerplant Activity Committee.

WARREN M. BEEVERS, who was sales engineer for the H. K. Porter Co., Inc., is now senior product engineer in the company's Thermoid Division.

Heim

Cowman

Smart

PHILLIP R. HEIM has been elected a vice-president of Royal Industries, Inc., and president of its Vard Division at Pasadena, Calif. Heim joined Vard in 1950 and has served as executive vice-president and general manager for the past year.

Royal Industries, Inc., designs and manufactures precision equipment for the nuclear and aerospace industries.

THAYER M. COWMAN, formerly manager of Detroit sales, Columbus Bolt & Forging Co., has been made director of sales. Replacing him as manager of Detroit sales is **DONALD J. CLARK,** previously sales engineer.

JAMES D. SMART has been appointed power steering sales supervisor for the Mobile Hydraulics Division at Vickers, Inc., a division of Sperry Rand Corp. In addition he will develop the sale and application of Vickers pumps.

Smart joined Vickers in 1958 as an application engineer.

HENRY J. GILMARTIN has been made service sales manager of the Hyatt Bearings Division of GMC. He was formerly manager of the Hyatt Detroit zone and will continue to operate from Detroit.

JOHN A. PHILPOTT, previously sales engineer, has been made assistant manager of the Hyatt Chicago zone.

ANASTASIOS S. HALKIDES is heating and power planning engineer with Ford-Werke A.G. in West Germany. Prior to this position, Halkides worked as chief mechanical engineer for the Frank E. Basil Co., Inc., in Athens, Greece.

DONALD D. NECESSARY, previously an engineering draftsman, has been made design engineer for seal development for the Caterpillar Tractor Co. He is also responsible for the investigation of seal problems in all the company's engineering departments.

GARNET L. GILLESPIE is a patent examiner for the Civil Service Commission of Canada. He was formerly in the Service, as second in command, armoured regiment L.A.D.

JAMES J. McGRAW has recently retired from the oil industry after 35 years. He was a lubrication engineer, handling fleet sales for Valvoline Oil Co., a division of Ashland Oil & Refining Co. McGraw became an associate member of SAE in 1945.

MAYNARD J. ISLEY is the first of the new specialist engineers in the recently established Applied Research Division of Studebaker-Packard Corp. He was previously chief project engineer at the Missile Division of Chrysler Corp.

Among SAE Enrolled Students

who have entered industry

EUGENE G. CANTEMIRY . . . University of Pittsburgh . . . test engineer, Automotive Division, Aberdeen Proving Ground.

E. M. DOBRINSKY . . . University of Detroit . . . maintenance engineer, Steel Division, Ford Motor Co.

MARION E. FORD . . . San Jose State College . . . service engineer, Hiller Aircraft Corp.

RONALD HORN . . . Academy of Aeronautics . . . aircraft mechanic, Maintenance & Service Aircraft, Inc.

KRISHNAN RAMASWAMI . . . Madras Institute of Technology . . . graduate apprentice, Messrs. Ashok Leyland Ltd., India.

EDWARD R. SCHNOES . . . Michigan College of Mining and Technology . . . assistant to chief engineer, Sherwood Brass Works.

WILLIAM R. TWA . . . Parks College of Aeronautical Technology . . . project engineer, Flight Control Branch, Wright-Patterson Air Force Base.

DAVID VEENSTRA . . . University of Detroit . . . electrical engineer, Shaw Box Crane Co.

graduate work . . .

GUBBI S. KUMARASWAMY . . . Madras Institute of Technology . . . working for M. S. (I.C.E.) at Engineering College, Guindy, Madras, India.

Obituaries

V. J. BARCLAY . . . (M'46) . . . production manager, Pacific Truck & Trailer Ltd., Vancouver . . . died September 4 . . . born 1896.

THOMAS W. CLAVELL . . . (M'45) . . . mechanical engineer, Dynamic Developments Inc. . . . died July 26 . . . born 1904.

JAMES H. COOLIDGE . . . (A'43) . . . vice president, Thompson Ramo Wooldridge Inc. . . . died July 14 . . . born 1898.

JOHN GOLDHAMMER . . . (M'51) . . . lubrication specialist, National Oil & Supply Co. . . . died June 1 . . . born 1903.

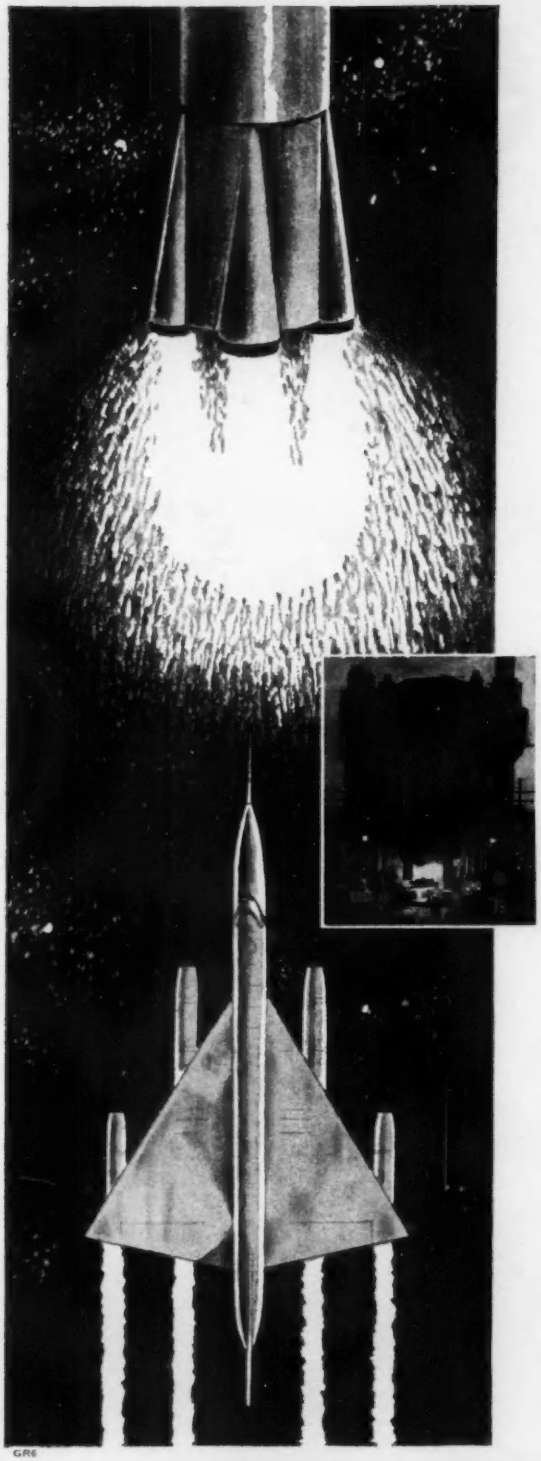
PHILIP J. KENT . . . (M'20) . . . engineering & sales consultant; formerly executive engineer, Electrical Division, Chrysler Corp. . . . died April 16 . . . born 1890.

HOMER T. LAMBERT . . . (M'57) . . . research engineer, Disc Brake Division Auto Specialties Mfg. Co. . . . died March 28 . . . born 1884.

MARION F. STEINBERGER . . . (M'27) . . . manager, highway transportation, Baltimore & Ohio Railroad Co. . . . died June 21 . . . born 1887.

WILLIAM MEANY . . . (A'59) . . . garage foreman, Niagara Mohawk Power Corp. . . . died March 21 . . . born 1910.

JOHN W. WATSON . . . (M'14) . . . president, John Warren Watson Co.; (once chairman of the Philadelphia Section) . . . died September 8 . . . born 1882.



Forging a metal spectrum for any flight environment

Whether design criteria be Mach 2 or escape velocity — the part a wing spar or rocket motor nozzle — most of the significant advances in forging conventional, exotic and refractory materials come from Wyman-Gordon. Here, technical breakthroughs in size, complexity and strength-to-weight ratios of forged airframe hardware and propulsion components have materially raised performance ceilings for every type of vehicle — global bomber to deep space probe capsule. Always impatient with state-of-the-art concepts, Wyman-Gordon engineers and metallurgists constantly explore ways to bring hitherto "unforgeable" metals and alloys into operational use — broadening the spectrum of ultimate-performance materials available for advanced vehicle designs. Consultation on your project requirements can help achieve better correlation of materials to service environment.

CURRENTLY FORGING THESE AERO-SPACE MATERIALS

Aluminum	Beryllium
Titanium	Molybdenum
Magnesium	Tantalum
Columbium	Zirconium
Hafnium	Tungsten
Inco 718	René 41
Astroloy	Waspaloy
Stainless steels	Vacuum-melt alloys
Nickel-base alloys	Iron-base, high-temperature alloys
High-strength die steels	20-27 Nickel steels

EST. 1883

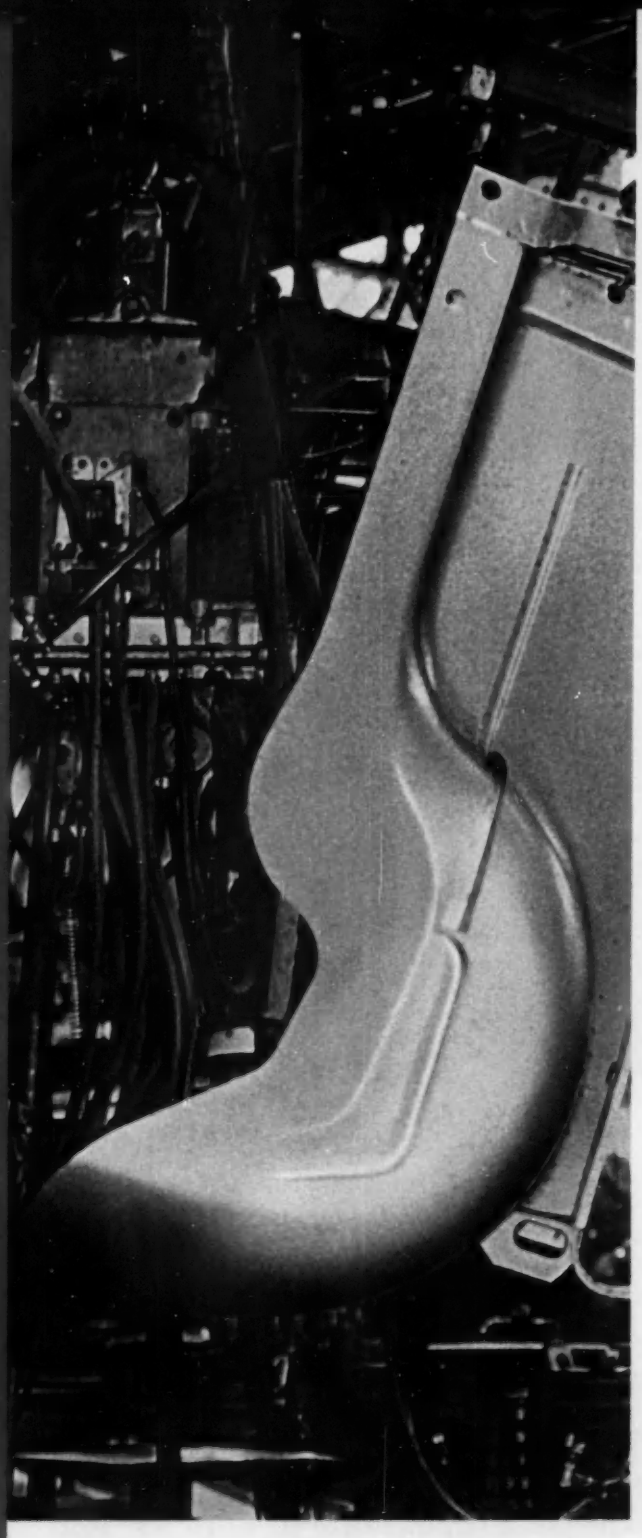
WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS WORCESTER MASSACHUSETTS DETROIT MICHIGAN

GRAFTON MASSACHUSETTS LOS ANGELES CALIFORNIA PALO ALTO CALIFORNIA FORT WORTH TEXAS,



DRAW

New Youngstown rolling and annealing capacity means ready availability of higher quality sheet steel

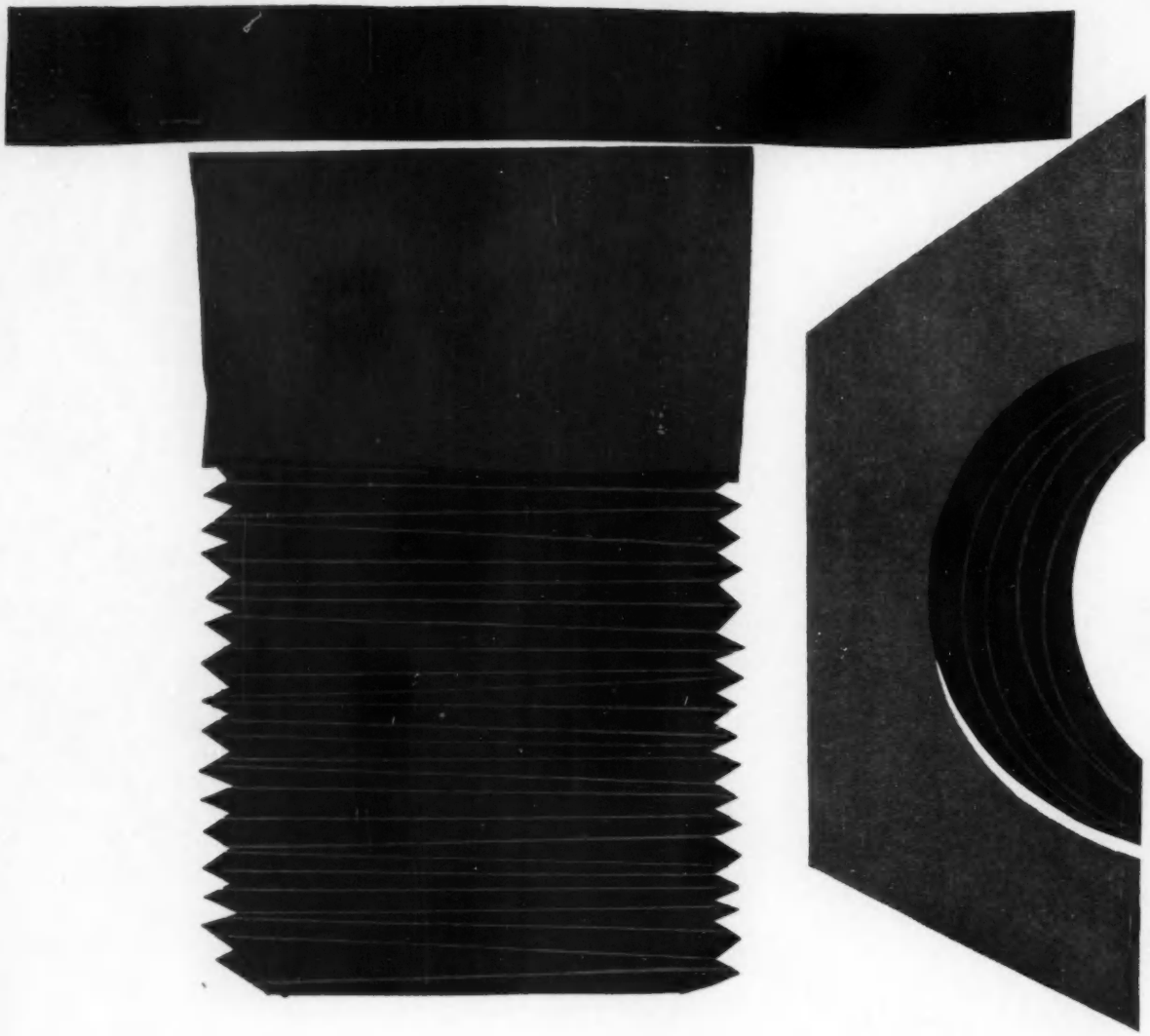
New sheet steel from Youngstown thrives in an atmosphere all its own. In 50 new stack annealing furnaces, Youngstown sheet takes on the exact grain structure and degree of plasticity you need for forming. You get the precise working characteristics required for mild or deep drawing quality.

Quality control in annealing is only a part of Youngstown's sheet story. A modernized 79" hot strip mill with electronic testing devices and automatic gauge control equipment assures you of more uniform quality steel sheet. This giant mill rolls huge 38,000 pound coils, delivers fewer welds, reduces your coil "down time." Prior to annealing, cold tandem mills reduce thickness to strict tolerances and give the sheet its exacting finish.

Order new Youngstown sheet in widths from 24" to 72". Use it in mild and deep draws. Work with it. You'll find it delivers all the qualities you need. Specify Youngstown sheet from 28 Youngstown District Offices or from your nearby Steel Service Center. Specify Youngstown's new annealing process. Specify softness. Or tempered hardness. You can depend on getting precisely what you want, when you choose Youngstown sheet.

Youngstown – growing force in steel

For full details on Youngstown sheet and annealing write: Dept. 11-D,
The Youngstown Sheet and Tube Company, Youngstown, Ohio



imagineering is the bold new look at Screw & Bolt that says "infinite design capability." Imagination, coupled with engineering, has led to endless new product design developments in fasteners and other threaded parts. ■ Need a new design fastener or threaded part where standard shelf items just won't fit? Clip this ad to your letterhead and Screw & Bolt's sales engineers will put *imagineering* to work for you.

VMA 9397

SCREW AND BOLT CORPORATION
OF AMERICA • P.O. BOX 1708, PITTSBURGH 30, PA.
Plants: Pittsburgh, Pa. Gary, Ind. Southington, Conn. Norristown, Pa. • Warehouses: Portland, Ore. Denver, Colo. Atlanta, Ga.

Imagineering... for greater fastener progress

Farm Machine Design On Eve of Great Advance

Based on paper by

JOHN GALE,
G. T. SCHARFENBERG,
and J. N. POLIVKA
Scharfenberg-Polivka-Gale, Inc.

IF FARM implements progress as much in the next 100 years as they have in the past century, the most visionary forecast will probably be conservative. The world's exploding population must be fed and clothed and creative effort must be applied to develop the techniques and machines to provide such development.

Existing power units which enable one man to perform a variety of jobs will soon be obsolete. Super light materials coupled with radical new power sources will make still-undreamed-of machines a reality. Automation will become as important to farming as it is to industry. The master of the automated implement will be protected from heat and cold and perhaps relax in a central location to watch his mobile equipment via television as it operates miles away under his remote guidance.

What lies ahead is no more fantastic than our combines would seem to the 19th century man swinging his cradle at harvest time. This is the challenge to be met for the benefit of all mankind.

■ **To Order Paper No. 404B . . .** from which material for this article was drawn, see p. 6.

Retarder Capacity Varies With System

Based on paper by

E. C. MAKI
International Harvester Co.

A 65,000 lb GCW vehicle descending a 6% grade at 40 mph requires a total retarding effect of 415 hp to maintain a constant speed. About 225 hp will be absorbed by air resistance, tire friction, chassis friction, engine friction, and other braking devices. This leaves 190 hp to be absorbed by the vehicle brakes or the retarder. How successful the retarder will be in absorbing kinetic energy will depend on its capacity. And the absorbing capacity of the retarder, in turn, will depend on the type of system used.

The capacity of the hydraulic and disc brake retarders is controlled by the physical size or diameter of the unit, but a major limitation on retarder capacity is the heat capacity of the engine cooling system. In highway service, this isn't a serious limitation because any engine cooling system that is adequate for the engine on the uphill pull will be adequate for the retarder on the downhill side. But it does mean that the engine must be kept at a speed high enough to maintain adequate water and air circulation for the retarder cooling requirements.

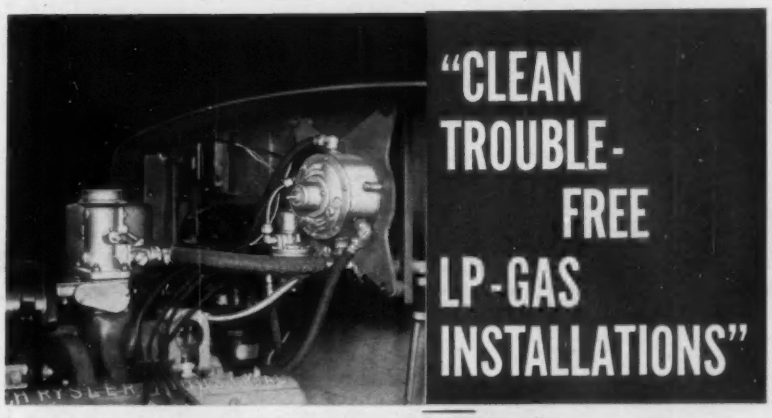
For retarders using an engine-driven cooling-oil circulating pump, the engine speed must be high enough to prevent overheating of the oil. The cooling-oil flow needed to absorb 200 retarder horsepower is about 25 gpm. The cooling-oil pump is generally sized to provide this flow at fairly high engine speeds to reduce cost, weight, and parasitic power loss.

Some heavy-duty models use direct water "boil off" or evaporation and are limited in capacity by the size of the water reservoir instead of the size of the engine cooling system.

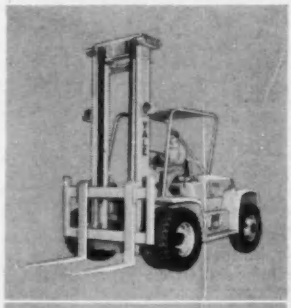
The electric retarder is energized by battery voltage and obtains its cooling by direct heat transfer to the atmosphere and is, therefore, not sensitive to engine speed. The capacity of this unit is limited by the cooling area exposed to the atmosphere, the condition of the cooling surfaces, the air flow past the unit, and to variations in atmospheric conditions.

The exhaust brake or engine com-

continued on p. 130



...EVERY TIME WITH CENTURY®



YALE CHOOSES CENTURY BECAUSE

... Century LP-Gas Carburetion Equipment is especially designed to meet every OEM requirement. Simplicity of carburetion equipment requires only minor adjustment. Installations are complete at the factory ... ASSURING CUSTOMER SATISFACTION IN THE FIELD.

Remember, Century Equipment is Factory Mutual approved, and U/L approved, where necessary, and backed by a complete factory trained national distributor and dealer organization.

There is a Century LP-Gas Carburetion system for factory installation or field conversion for all makes and types of industrial trucks and equipment.

SEND FOR NEW LITERATURE

Export Sales: Sin Par Automotive Div. Singer Products Co. 95 Broad Street New York 4, N. Y.

CENTURY
LP-GAS CARBURETION

BW

CENTURY GAS EQUIPMENT
Marvel-Schebler Products Div.
Borg-Warner Corporation
Decatur, Illinois

build reliability, flexibility, versatility into your hydraulic system . . .

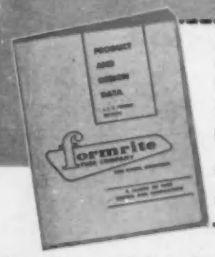
SPECIFY

formrite

S.A.E. 37° FLARE J.I.C. FITTINGS

Formrite J.I.C. Fittings range in size from ⅛" to 2" Tube O.D. Produced from steel bar stock and zinc-plated, they are made to S.A.E. dimensions. And *remember* . . . when you deal with Formrite, you deal with a company with a conscience. O.E.M.'s who do, have come to depend on its fluid transfer engineering ability, manufacturing techniques, testing methods and complete servicing.

Please fill in coupon below for further information . . .



FORMRITE TUBE COMPANY
P.O. Box 118 Two Rivers, Wisconsin
Please send me complete information on your S.A.E. 37° FLARE J.I.C. FITTINGS.

Name _____

Address _____

City _____ Zone ____ State _____

Formrite specializes in the design and fabrication of precision formed metal tubes for fluid transfer lines. In addition, it has complete lines of tube fittings in all standard shapes and a large range of sizes. Forgings, castings and flange mounted fittings are also available and can be machined to exacting requirements.

a leader in tube design and fabrication

formrite

TUBE COMPANY

TWO RIVERS, WISCONSIN

MEDINA, OHIO

pression retarders are of two types: one which builds up pressure in the exhaust system, and the other which changes the exhaust valve timing to take advantage of the pressure build-up in the exhaust system. This maximum allowable pressure varies from about 20–55 psi. The higher pressure systems may require a special stainless steel manifold. The retarding ability of the exhaust brake on a 700 cu in., 4-cycle engine at 2000 rpm is about 18 hp at 20 psi and 35 hp at 55 psi (additional exhaust back pressure).

The retarding ability of the exhaust brake with changing valve timing is limited by the compression ratio of the engine, engine condition, and the ability of the exhaust valves to exhaust the pressure in the time available. A 700 cu in., 4-cycle engine with a 16/1 compression ratio running at 2000 rpm could produce a retarding effect of about 130 hp if all of the compression energy in the combustion chambers were exhausted to zero psi (gage).

■ **To Order Paper No. 396C . . .** from which material for this article was drawn, see p. 6.

Canard Ducted-Prop VTOL Rates Best In Douglas Study

Based on paper by

CHARLES O. GUNDERSON

El Segundo Division, Douglas Aircraft Co., Inc.

THE OPTIMUM VTOL airplane for medium-range and medium-speed operations is the canard ducted-propeller configuration, with shafted transmission of power from fuselage-mounted free-turbine engines, according to Douglas design studies.

Canard Configuration

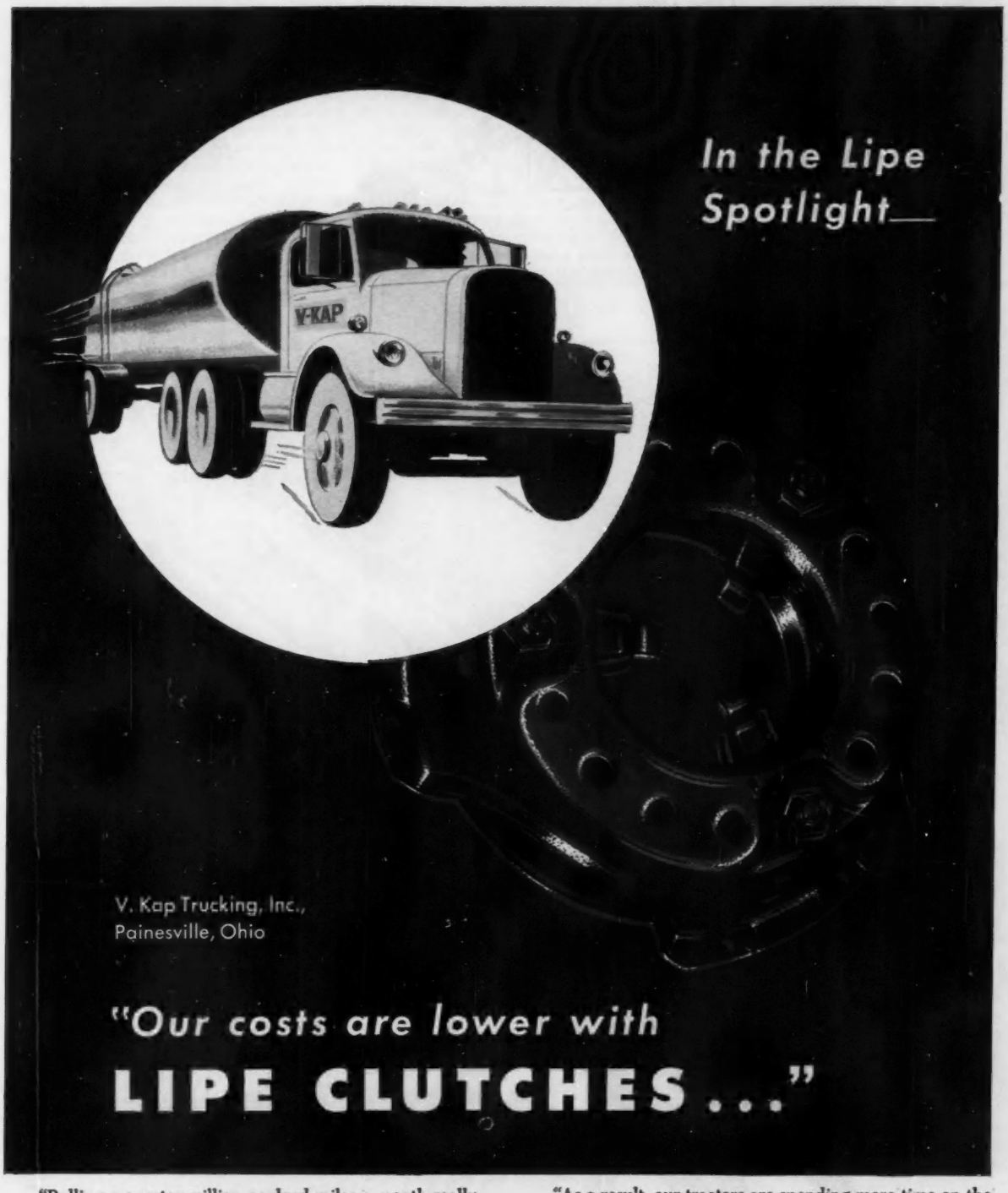
The canard arrangement of VTOL aircraft combines propulsion, lift, and control systems, and eliminates the need for tail rotors or reaction control devices.

It provides a stable 4-point lift system; during hover, the four ducted propellers support the aircraft. The 4-point system:

- Minimizes the problem of balance about the airplane center of gravity.
- Compensates for a large change in center of gravity.
- Supplies ample control force to compensate for airplane trim changes during the transition from vertical to horizontal flight.
- Reduces the wing span required, which allows a compact design.

In the canard arrangement, horsepower is converted to thrust through

continued on p. 133



"Rolling a quarter-million payload miles a month really puts the pressure on our 54 tractors," reports Raymond Luhta, service manager for V-Kap Trucking, Inc., Painesville, Ohio.

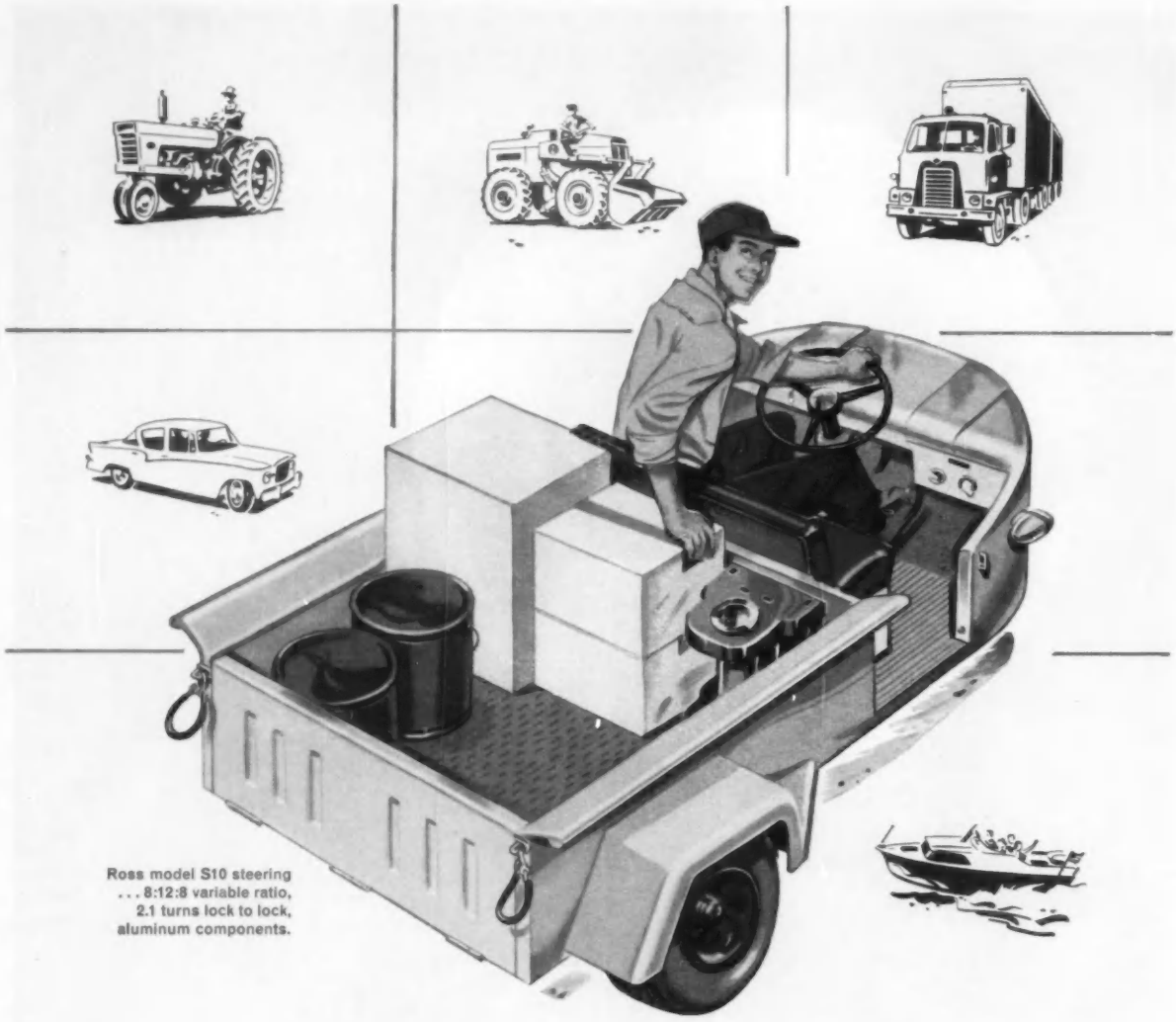
"A performance check showed us that units with Lipe clutches were logging about 150,000 miles per clutch. Now our entire fleet (Whites, Fords and Internationals) is equipped with Lipe Clutches, either as original equipment or on a continuing replacement basis.

"As a result, our tractors are spending more time on the road and less in the shop."

Reasons like these – better mileage, more capital equipment use and lower maintenance cost – reveal why so many fleets are converting to Lipe Heavy-Duty Clutches. Make performance prove to you, too, that...

LIPE DELIVERS IN THE CLUTCH

© LIPE—ROLLWAY CORPORATION, SYRACUSE, NEW YORK



Ross model S10 steering . . . 8:12:8 variable ratio, 2.1 turns lock to lock, aluminum components.

I have Ross variable-ratio steering, too!

Ross

● Here's a shop "mule" with no balky handling habits. Responsive variable-ratio steering keeps it "narrow and nimble" for crowded aisles and tight corners. Whatever *your* steering needs may be—manual or power, constant or variable ratio—Ross invites your inquiry.

STEERING

ROSS GEAR & TOOL COMPANY, INC.

Ross Division, Lafayette, Indiana • Gemmer Division, Detroit, Michigan

four shaft-interconnected propellers driven by four engines. If any one of the engines fails, the four propellers still develop balanced thrust because the horsepower of the remaining three engines is equally divided among the propellers automatically. During this failure, 82% of the total thrust is still available because of the propeller interconnection. (The horsepower of each of the remaining engines is converted to thrust, utilizing the area of 1⅓ propellers at reduced thrust loading.) In a noninterconnected version, asymmetric thrust would be developed during an engine failure, since one propeller would stop and only 75% of the total thrust would be available.

Free Turbine Engines

Free turbine engines are preferred because their broad rpm operating range efficiently matches the propeller (high) take-off and (low) cruise rpm requirements. The very narrow rpm operating range of the fixed turbine engine cannot be efficiently adapted to most VTOL propeller designs.

The hot gas or fluid coupling between the free turbine and the gas generator is ideal for coupling several engines together on a common shaft. The gas coupling allows sufficient turbine slippage or gas-generator-to-turbine mismatch, so power adjustments or throttle settings of individual engines are not extremely critical. On some multiengine VTOL airplane configurations, cruise flight can be accomplished with only half the engine operating — either by allowing the underpowered free turbines to be driven by the operating engines through interconnecting shafting or by using small lightweight overrunning clutches for complete disengagement.

■ **To Order Paper No. 428B . . .**
from which material for this article was drawn, see p. 6.

Aluminum Makes Good In Off-Highway Bodies

Based on paper by

R. A. ESMONDE
Aluminum Co. of Canada, Ltd.

OPEN PIT mine operators, construction companies, and the like, could easily turn to using aluminum off-highway bodies. To insure such a switch, aluminum suppliers and body fabricators will have to do three things:

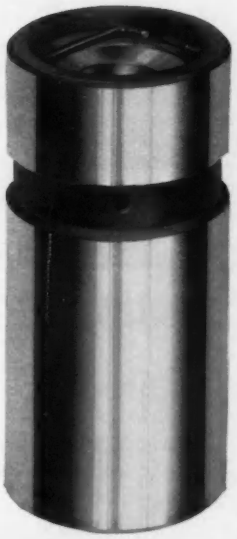
1. Strive to improve body design. This has to be done to bring body weight down to a minimum, compatible with good service and simple fabrication, so that the end cost of the body will be lower. If this is done, aluminum can meet all competition from steel, even when body weight is substantially reduced by using high-strength, low-alloy steels.

2. Insure adequate welding by using correct welding procedures, edge preparation, and a sufficient number of weld passes.

3. Study the use to which the unit is to be used so that the body will meet requirements of design and construction.

Comparative operating data of a 19.2-yd aluminum body and a 14.8-yd steel body used in asbestos mining by John-Mansville of Canada, show a cost saving of $10 per hr for the aluminum body because of the extra load carried. The aluminum body cost twice as much as a steel body to fabricate so that the increased capital outlay for the vehicle (with chassis) was 7.6%. This increased cost, however, was paid off in 4.5 months of operation. Maintenance costs for the aluminum body were virtually nil for the first year and indications are that over a period of time they will probably be much less than for the steel bodies.

■ **To Order Paper No. 414A . . .**
from which material for this article was drawn, see p. 6.



for all engine applications

JOHNSON *tappets*

Keeping ahead with the latest tappet developments is a full-time job at JOHNSON PRODUCTS. All of our design engineering and manufacturing improvements go toward giving your engine the right kind of *tappet performance.*

We think the results speak for themselves: Johnson Tappets are *high in quality, competitive in price.* As tappet specialists, we welcome the opportunity to show you how well the job can be done.

Johnson TAPPETS

"tappets are our business"

JOHNSON JP PRODUCTS
MUSKEGON, inc. MICHIGAN

put power where you want it

Flexible shafts give the designer important new freedom in transmitting rotary power or control between two points. They enable you to position your power source and your driven part to best advantage . . . without worrying about obstructions, vibration, shock or alignment.

Even if the components are in relative motion to each other, you can still transmit power smoothly and economically.

Flexible shafts also reduce manufacturing costs . . . use fewer parts . . . eliminate cumbersome gears, drives, couplings, universals. With rigid connections gone, alignment and tolerance problems fade away, and installation is a snap.

Whatever your rotary transmission problem, there is a good chance that one of S. S. White's flexible shaft lines can solve it . . . *Standard, Pre-Engineered,* or *Custom-Designed* flexible shafts.

S. S. WHITE INDUSTRIAL DIVISION,
DEPT. 30F 10 East 40th Street, N. Y. 17, N. Y.

THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
New 4th Edition . . . Send for your free copy!

S.S.White
FIRST NAME
IN FLEXIBLE SHAFTS

Briefs of SAE PAPERS

continued from p. 6

tion; Caterpillar Tractor Co. undertook development to point that test procedure could be made available; test procedure ET-17, turned over to 15 laboratories for cooperative testing and experience developed; results obtained and future needs.

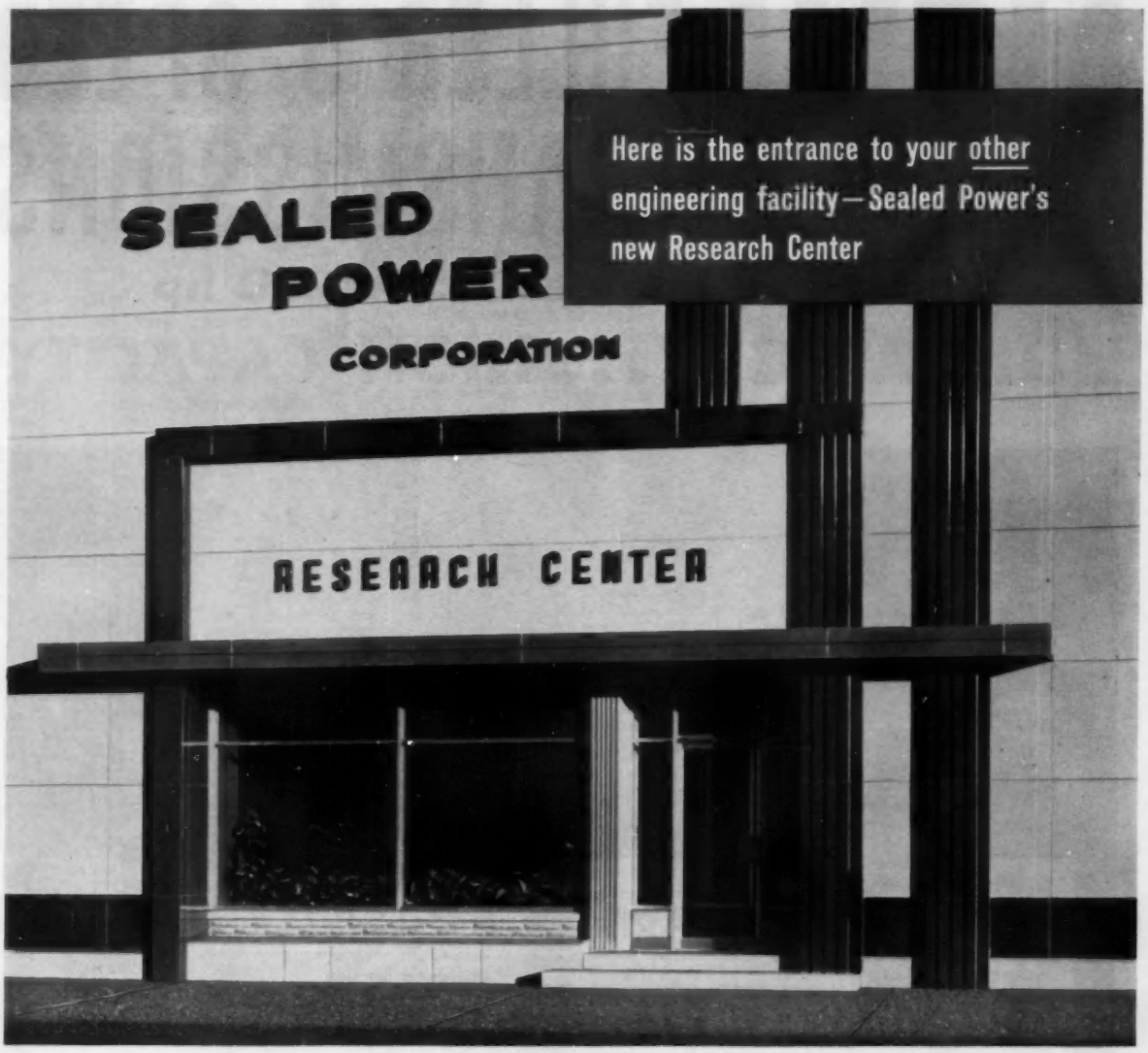
Development of Research Technique for Study of Oxidation Characteristics of Crankcase Oils in CLR Oil Test Engine, E. A. MARTIN. Paper No. 374C. Background and development of single-cylinder CLR Oil Test Engine, and objectives of work carried out by Coordinating Research Council; present status, severity, repeatability, and reproducibility of 11 specific cooperative programs carried out; future areas include improved or automatic control of off-gas, crankcase leakage, and pressure; investigation of better control of oil flow to test bearings.

Fuel Distribution by Exhaust Gas Analysis, L. S. LEONARD. Paper No. 379A. Experimental work at Ford Motor Co. to obtain data necessary necessary to draw empirical curves for relationship of exhaust gas constituents, carbon dioxide, carbon monoxide, and oxygen to air-fuel ratio, using present engines and fuels; use of infrared analyzers, Orsat analysis, and methods of correlation between exhaust gas composition and air-fuel ratio, independent of fuel composition, developed and illustrated by means of nomograph; method describing condition of fuel mixture by use of "mixture coefficient."

Use of Laboratory Ball Joint Test to Predict Chassis Grease Performance, A. C. HORTH, W. C. PATTENDEN, G. F. KELLER, J. PANZER. Paper No. 379B. Two of greases for which field data had been published earlier were tested under specified conditions; Grease A is lithium-calcium soap grease; Grease B, calcium acetate type, with average steady-state steering torque of 6.7 lb-ft, proved to be significantly better; laboratory and field data show that Grease B maintains lower friction in ball joints than Grease A; further differences established; effects of grease properties.

Laboratory Engine Method for Measurement of Detergency Effectiveness of Gasoline Additives on Carburetor Throttle Body Deposits, E. J. FUCHS. Paper No. 379D. Deposits, if permitted to form to critical level, cause engine malfunctioning or idling conditions and poor fuel economy; method to

continued on p. 137



Solving your problems

is a "specialty of the house" at Sealed Power

Oil consumption, bore finish, special rings . . . if you have a problem that has to do with engines bring it to Sealed Power.

Here in Sealed Power's spacious, elaborately equipped Research Center is a staff of skilled engine specialists . . . engineers, metallurgists, chemists. They are yours for the asking.

Following a coats-off discussion among this group, knotty problems have a way of being translated into specific means and methods of making engines act *right*.

After all, this is the group that developed Sealed Power's Stainless Steel oil ring . . . the ring that made automotive history because it licked the oil control problem in high compression engines.

Sealed Power PREFERRED PERFORMANCE

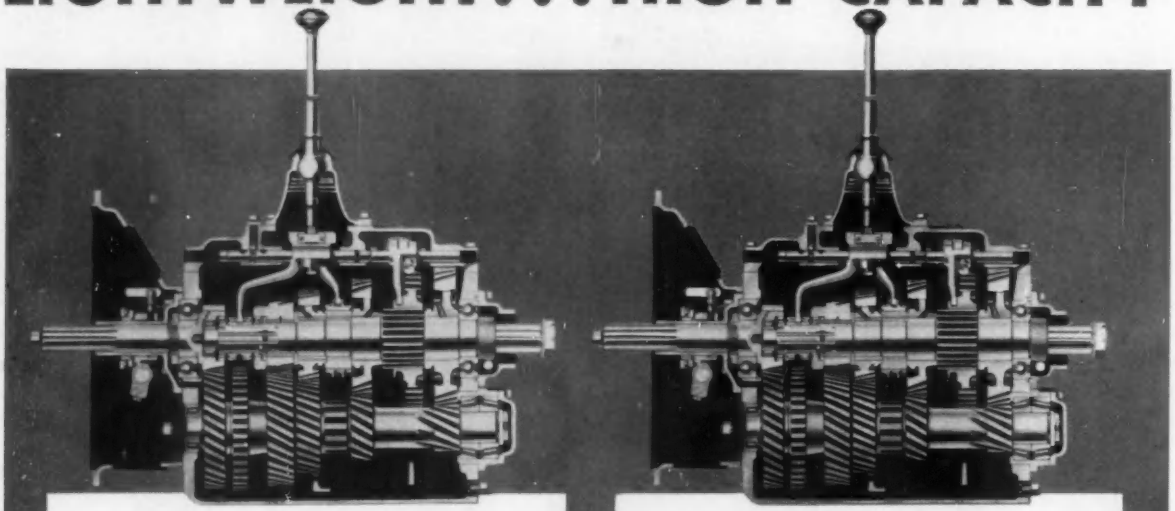
PISTONS • PISTON RINGS • SLEEVES • SLEEVE ASSEMBLIES • PRECISION CASTINGS
SEALING RINGS FOR ALL APPLICATIONS

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO • DETROIT OFFICE, 17600 WEST 8 MILE ROAD—PHONE 357-4141

NEW FULLER 5-SPEED TRANSMISSIONS

for diesel engines 195 to 250 hp

LIGHTWEIGHT... HIGH CAPACITY



Model 5-H-74 and 5-HA-74

designed for use with 2-speed auxiliaries, 3-speed auxiliaries, 2-speed axles.

GEAR RATIOS:	
5th	1.00
4th	1.17
3rd	1.98
2nd	3.61
1st	6.60
Rev	6.51

Model 5-HA-74—93 lbs. lighter with aluminum case and clutch housing.

Model 5-H-75 and 5-HA-75

designed for use with Fuller 4-C-75 4-speed auxiliaries and 3-speed tandem axles.

GEAR RATIOS:	
5th	1.00
4th	1.56
3rd	2.43
2nd	3.91
1st	6.60
Rev	6.51

Model 5-HA-75—95 lbs. lighter with aluminum case and clutch housing.

- Extremely high capacity-to-weight ratio
- Ideal gear ratios
- Wide gear faces
- Mainshafts of greater diameter
- High-capacity pilot bearings
- Helical gearing
- Jaw clutch engaged—for easy shifting

For maximum versatility and reliability in your operation, Specify the Model . . . SPECIFY

FULLER TRANSMISSION DIVISION

EATON MANUFACTURING COMPANY

KALAMAZOO, MICHIGAN

Sales & Service: West. Dist. Branch, Oakland 6, Cal. • Southwest Dist. Office, Tulsa 3, Okla. • Automotive Products Co., Ltd., Brock House, Langham St., London W.1, England, European Rep.

Briefs of SAE PAPERS

continued from p. 134

study effectiveness of additives, whereby 2 different fuels can be compared simultaneously using modified 2-barrel carburetor; additives can be evaluated for their effectiveness in prevention of deposit formation or removal of previously formed deposits.

Effect of Fuel Components on Combustion Smoothness, D. W. FELDMAN. Paper No. 379G. Details of engine environment which could produce rumble and detection of its occurrence by means of pressure pickups monitoring combustion pressure and vibration pickup responding to engine vibrations; second system is much more simple and equally effective; test equipment, fuels, and procedure; results obtained.

Technique for Evaluating Effects of High Frequency Vibrations on Greases Used in Automatic Brake Adjusters, W. F. SCRUGGS, T. W. SELBY. Paper No. 379H. Loss of lubricant and excessive friction was suggested as cause of malfunctions in automatic brake adjusters during road tests for which HF vibrations and/or high temperatures might be responsible; study of these effects on 3 automatic brake adjuster greases using sonic generator and transducer; predicted superiority of bentonite clay grease as compared to graphite and molybdenum disulphide grease.

GROUND VEHICLES AND MARINE

Lean Fuel/Air Mixtures for High-Compression Spark-Ignited Engines, J. A. BOLT, D. H. HOLKEBOER. Paper No. 380D. Study of factors which limit use of lean mixtures in test engine having compression ratios up to 16, to determine influence of increased compression ratio upon ability to use lean mixtures; effect of measured mass fuel-air ratios and compression ratio upon indicated thermal efficiency of engine burning propane show improvement with increased compression ratio; increase in inlet mixture temperature or compression ratio makes it possible to burn leaner mixture.

New I.F.P. Process for Engine Combustion: Variable Air-Fuel Ratio Spark Ignition Engine, J. BAUDRY. Paper No. 380F. Research at Institut Francais du Petrole relating to conditions for employment of lean mixtures; system for heterogeneous mixture formation by carburetion developed at IFP; mixture is produced in combustion chamber by dividing carbureted mixture into 2 separate streams of different fuel-air ratios; experiments carried out on Renault-CNRS single cylinder engine and results; application of IFP process to automotive engines.

Field Experience with GMT-305 Gas Turbine in Military Applications, R. W. GUERNSEY. Paper No. 383A. General description of engine and reasons for development by field tests; information as to engine and vehicle performance was obtained from tracked vehicle, Navy Personnel Boat, amphibious lighter TRECOM LARC-5, ERDL DW15 tractor, INCO ore hauler, and Navy Cyclic Generator Set; most significant performance data compiled and presented in tabular form for each application.

MATERIALS

Metallurgical Bonding in Cylinder Construction, M. G. WHITFIELD. Paper No. 369A. Summary of successful bonded cylinder applications to date covering aircraft, automotive, tanks, auxiliary and outboard engine power plants; reference made to Al-Fin metallurgical bond which is intermetallic compound of metals being joined, usually steel or iron and aluminum; alloys used; process involves immersion into bath of molten aluminum to form alloy bond; thermal properties, effects on steels, and design considerations.

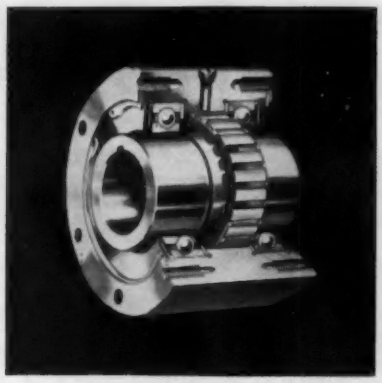
Development of Tibon Hard Chrome Plated Cylinder Bores, L. W. RAYMOND, A. K. WOOD. Paper No. 369B. Use of aluminum as material for internal combustion engines; history of chromium plating and chromium plating of aluminum; techniques of chromium plating 2- and 4-cycle aluminum cylinders; review of successful applications; requirements of cylinder prior to plating and requirements of plating process.

Transplant Coated Aluminum Cylinder Bores — Physical Properties of This New Protective Coating in Comparison to Known Processes, A. F. BAUER. Paper No. 369C. Development of combination spray and die casting method by National Lead Co., by means of which liners for water cooled engines and cylinder barrels for air cooled engines can be produced with wear resistant protective coat of

continued on p. 141

These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.



Higher over-running speeds with Formsprag

HPO CLUTCHES

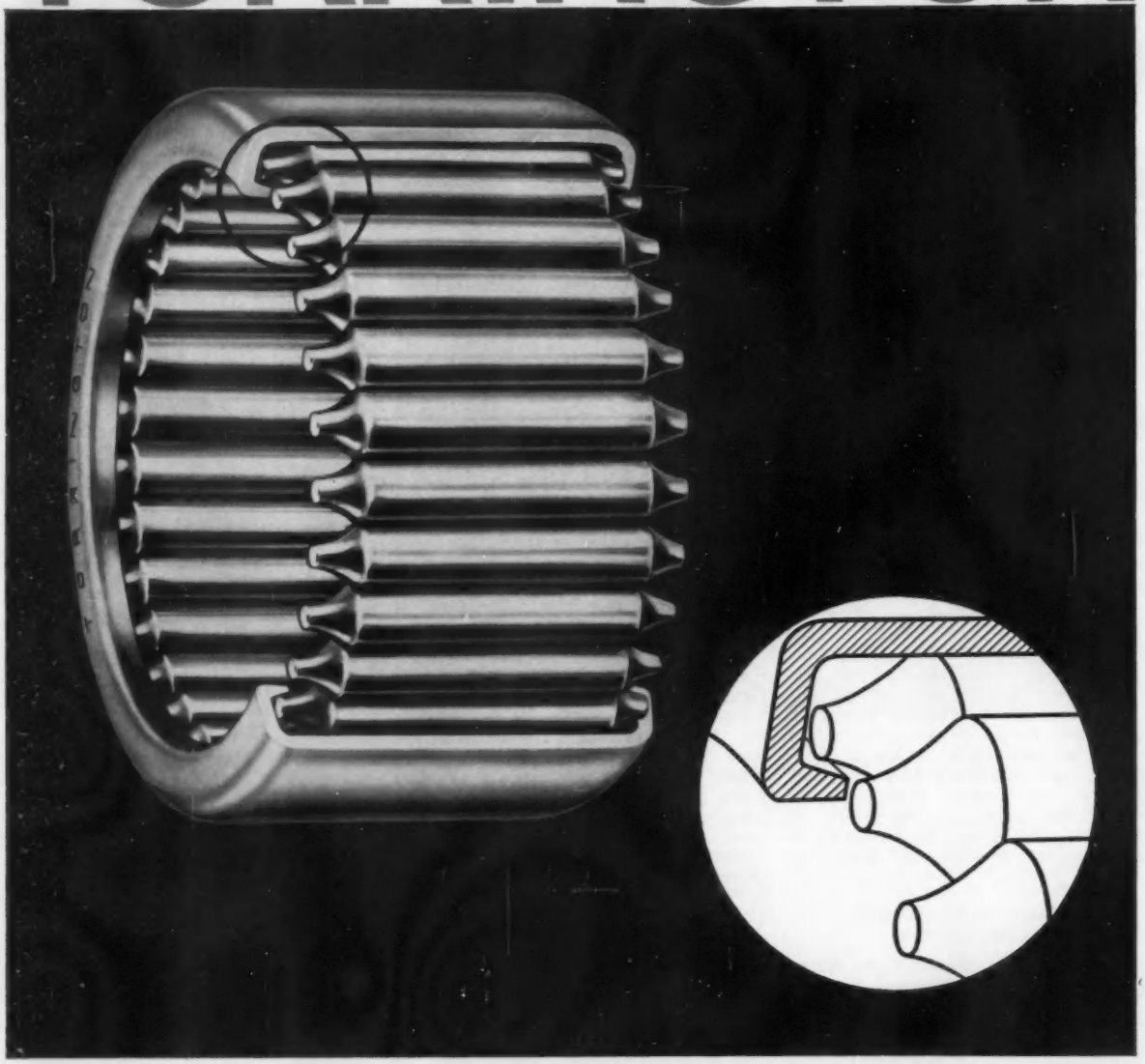
Exclusive chromium-carbide alloy "Formchrome" sprags held in precise position with a new retainer design permit up to *30% higher operating speeds* with the same life span and up to *70% longer clutch life* when operated at same RPM as ordinary clutches.

- More capacity for a given size and weight of clutch
- Fewer internal stresses resulting from full complement of sprags.
- Rated torque capacities 140 to 13,500 lbs. ft.
- Bore sizes .500" to 6.000".

GET COMPLETE DATA
Write for
Formsprag Catalog 105B

FORMSPRAG COMPANY
23583 HOOVER ROAD, DEPT. 116
WARREN (DETROIT), MICHIGAN
Precision Power Transmission Products

TORRINGTON



NEVER A SLIP 'TWIXT THIS CUP AND LIP

The Torrington Drawn Cup Needle Bearing is one of the easiest of all bearings to install and maintain. Secret is the turned-in lip construction. This lip positively retains the rollers... keeps them in position as a complete unit during all handling and assembly operations. Install it by simple press fit. No snap rings or shoulders are necessary.

That's not all. The Torrington Drawn Cup Needle Bearing also gives you a higher radial load capacity than any other bearing of comparable size. Precision rollers insure smooth, highly efficient performance, with a minimum of starting and running friction.

This bearing is compact, lightweight, economical. Its unit cost is surprisingly little. For details on how the Torrington Drawn Cup Needle Bearing can help your product, call or write Torrington... pioneer in needle bearings and maker of every basic type of antifriction bearing.

progress through precision

TORRINGTON BEARINGS

THE TORRINGTON COMPANY

Torrington, Connecticut • South Bend 21, Indiana

HEADQUARTERS

for tough valve gear problems

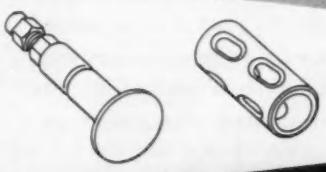
When you're facing difficult problems involving valve gear, the men to see are Chicago's tappet engineers. For, in 25 years of specialization on valve train parts, we have encountered and solved many problems similar to yours.

Applications, such as those illustrated, are typical examples . . . and the operational records established by Chicago tappets of all types in more than 25,000,000 engines are the best testimonial to their success in meeting the toughest industry requirements.

Even when your engine does not present unique requirements in valve gear design, checking with Chicago can often assure a performance bonus. Chicago's hydraulic tappets, for example, assure longer trouble-free life, reduced starting noise, and quieter operation.

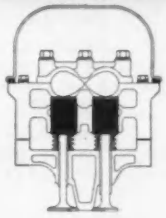
For Any Engine

Car, truck, tractor, diesel . . . aircraft, outboard, power mower, or industrial . . . whatever your type of engine, big or small . . . it will pay you to consult Chicago's development engineers *while you are still in the preliminary design stages.*

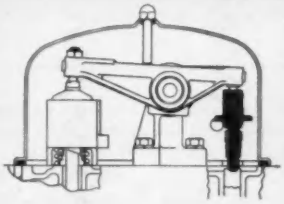


Write or wire our Tappet Division today

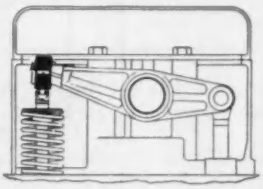
Hydraulic and Mechanical Tappets (Barrel or Mushroom Type) of Alloy Steel, Hardened Alloy Cast Iron, Chilled Iron, or Alloy Chilled Iron • Push Rods • Adjusting Screws



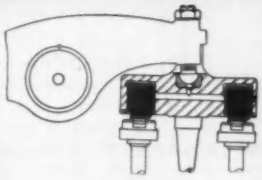
Hydraulic Inverted Cup Type Unit



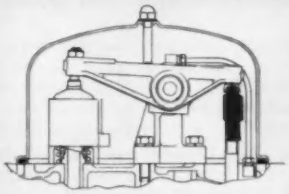
Push Rod Type with Compression Release Application



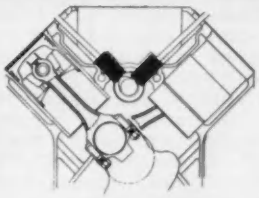
Threaded Type Rocker Arm Unit



Dual Valve T-Bridge Hydraulic Application



Hydraulic Unit on End of Push Rod



V-8 Automotive Hydraulic Tappet Application

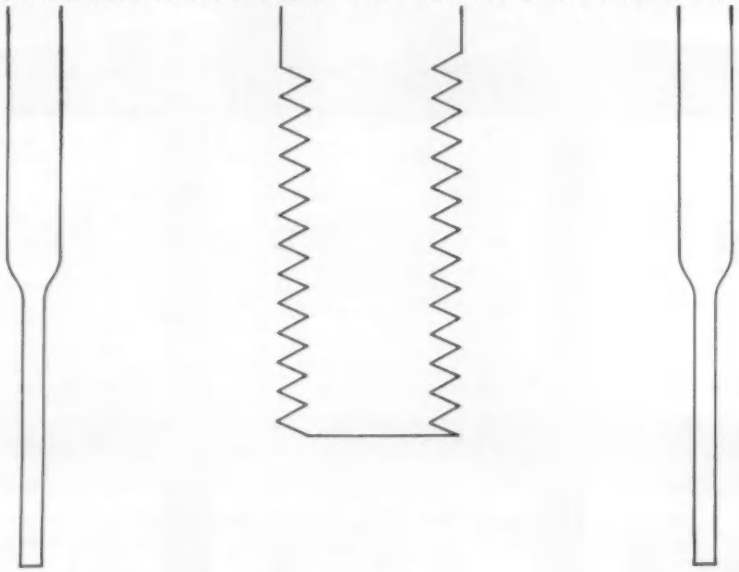
THE CHICAGO SCREW COMPANY

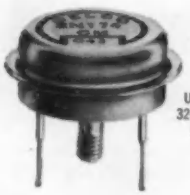
ESTABLISHED 1872 • DIVISION OF STANDARD SCREW COMPANY

2701 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

TAKE A SECOND LOOK

IT'S THE 2N174—PART OF DELCO RADIO'S POWER TRANSISTOR FAMILY WHICH HAS PROVED ITS STUFF FOR YEARS IN HUNDREDS OF MILITARY AND INDUSTRIAL APPLICATIONS: MISSILES, COMMUNICATIONS, DATA PROCESSING, AND ULTRASONICS, TO NAME A FEW. THIS MULTI-PURPOSE PNP GERMANIUM POWER TRANSISTOR HAS THE HIGH PERFORMANCE AND VERSATILITY TO MEET OR EXCEED THE MOST RIGID ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS. ◖ DESIGNED FOR GENERAL USE WITH 28-VOLT POWER SUPPLIES, THE 2N174 MAY ALSO BE USED WITH 12 VOLTS WHERE HIGHER RELIABILITY IS DESIRED. MAXIMUM EMITTER CURRENT—15 AMPERES, MAXIMUM COLLECTOR DIODE RATING—80 VOLTS, THERMAL RESISTANCE—BELOW .6°C/W AND MAXIMUM POWER DISSIPATION—50 WATTS AT 71°C, MOUNTING BASE TEMPERATURE. THE 2N174'S LOW SATURATION RESISTANCE PROVIDES HIGH EFFICIENCY IN SWITCHING OPERATIONS. ◖ LIKE ALL DELCO TRANSISTORS, EVERY 2N174 MUST PASS AT LEAST A DOZEN ELECTRICAL AND ENVIRONMENTAL TESTS—BEFORE AND AFTER AGING—BEFORE IT LEAVES DELCO RADIO'S LABORATORIES. THIS 200 PERCENT TESTING, COMBINED WITH FIVE YEARS OF REFINEMENTS IN MASS PRODUCTION, MEANS CONSISTENT UNIFORMITY IN THE PRODUCT . . . AT A LOW PRICE. ◖ THE 2N174 IS JUST ONE OF MANY DEPENDABLE TRANSISTORS PRODUCED BY DELCO RADIO TO SUPPLY ALL YOUR TRANSISTOR NEEDS. FOR MORE DETAILS OR APPLICATIONS ASSISTANCE ON THE 2N174 OR OTHER DELCO TRANSISTORS, CONTACT YOUR NEAREST DELCO RADIO SALES OFFICE.





Union, New Jersey
324 Chestnut Street
MUrdock 7-3770

Santa Monica, California
726 Santa Monica Blvd.
UPton 0-8807

Chicago, Illinois
5750 West 51st Street
POrtsmouth 7-3500

Detroit, Michigan
57 Harper Avenue
TRinty 3-6560

Syracuse, New York
1054 James Street
GRanite 2-2668

DELCO RADIO
DEPENDABILITY
RELIABILITY

DIVISION OF GENERAL MOTORS • KOKOMO, INDIANA

DELCO SEMICONDUCTORS NOW AVAILABLE AT THESE DISTRIBUTORS:

New York:
HARVEY RADIO CO., INC.
103 West 43rd St., New York 36, N. Y.
JU 2-1500

San Francisco:
SCHAD ELECTRONIC SUPPLY, INC.
499 South Market St., San Jose 13, Calif.
CY 8-0511

Detroit:
GLENDALE ELECTRONIC SUPPLY COMPANY
12530 Hamilton Ave., Detroit 3, Michigan
TU 3-1500

Boston:
GREENE-SHAW DISTRIBUTING CO.
341 Watertown St., Newton 58, Mass.
WO 9-8900

Philadelphia:
ALMO RADIO COMPANY
913 Arch St., Philadelphia, Pennsylvania
WA 2-5918

Baltimore:
RADIO ELECTRIC SERVICE
5 North Howard St., Baltimore, Maryland
LE 9-3835

Seattle:
C&G ELECTRONICS COMPANY
2221 Third Avenue, Seattle 1, Washington
MA 4-4354

Chicago:
MERQUIP ELECTRONICS, INC.
5904 West Roosevelt, Chicago, Illinois
AU 7-6274

Los Angeles:
RADIO PRODUCTS SALES, INC.
1501 South Hill St., Los Angeles 15, Calif.
RI 8-1271

Minneapolis:
GEORGE SPENCER, INC.
5305 Cedar Lake Rd., Minneapolis 16, Minn.
LI 5-8811

Birmingham:
FORBES DISTRIBUTING CO., INC.
2610 Third Ave. S., Birmingham 5, Ala.
AL 1-4104

West Palm Beach:
GODDARD, INC.
1309-11 N. Dixie, West Palm Beach, Florida
TE 3-5701 or WX-9000

Phoenix:
ASTRONICS, INC.
9310 North Central, Phoenix 20, Arizona
944-1551

Richmond:
MERIDIAN ELECTRONICS, INC.
1001 W. Broad St., Richmond 20, Virginia
EL 5-2834

Cincinnati:
UNITED RADIO, INC.
1314 Vine Street, Cincinnati 10, Ohio
CH 1-6530

Ask for a complete catalog

DELCO RADIO
DEPENDABILITY
RELIABILITY

Briefs of SAE PAPERS

continued from p. 137

extreme smoothness and high accuracy; bond qualities of transplant coat; field and dynamometer tests, and details of pilot plant and production facilities.

Profile of Aluminum Alloy Cylinder Bores, N. W. SMITH. Paper No. 369D. Development work at Aluminum Co. of America on 2- and 4-stroke cycle engines for compatible piston and cylinder materials, particularly with uncoated aluminum alloy cylinder surfaces in combination with coated and uncoated aluminum alloy pistons; wear test results of 4-stroke cycle aluminum bores and 2-stroke engines; summary of conclusions; wear rates of aluminum alloy cylinders are comparable to commercially used cylinder and cylinder-liner materials.

Improved Function and Reduced Cost Through Well Engineered Plastic Components, T. H. RISK, J. R. FORRESTER, Jr., R. P. SCHMUCKAL. Paper No. 381A. Increase of use of plastics is result of introduction of new materials, reduction in price, better understanding of properties, methods of fabrication, and end use; properties and potential use of nylon, acetal, polycarbonate, methacrylate, ABS materials, high-density polyethylene, and polypropylene; desired properties for expanded use.

Metals vs. Plastics: Performance — Key to Selection, M. W. RILEY, D. PECKNER. Paper No. 381B. Comparison of physical properties such as electrical resistance, thermal conductivity, weight, expansion, chemical resistance, and weatherability with mechanical properties, tensile strength, creep and cold flow, rigidity, strength-to weight ratio, and maximum operating temperature; reference made to 1962 Valiant instrument housing of acetal, and 1962 Lancer housing which is die cast in zinc providing comparable performance at identical costs; comparison of production run will show actual costs of each.

New Members Qualified

These applicants qualified for admission to the Society between August 22, 1961 and September 22, 1961. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group: Rramwell Herbert Booth (A), Robert L. Hudson (A), Victor Lawrence Humaniuk (J), Ernest Paul Villett (A).

Baltimore Section: Wesley Homer Fesler (J), George E. Maffey, Jr. (J).

British Columbia Section: Christopher Charles Perry (A), Leslie Smith (A).

Buffalo Section: Philip Fred Alesso (J), Charles Cook Eckles (M), Russell S. Genco (M), Donald William Winfield (J).

Central Illinois Section: Richard C. Busby (J), James Thomas Hammond (A), Robert Hennelly (J), Calvin David Loyd (M), Ralph E. Master (J), Robert Joseph Vogel (M).

Chicago Section: Gene D. Amante (M), Leonard Simon Banaszak (J), Paul Aloysius Bauer (M), Howard E. Hruska (M), Vernon C. Judd (A), Edward William Luecht (A), James Ladd Srch (M).

Cleveland Section: James Raymond Barrett (J), Walter E. Boyce (M), Joseph Gerald Casey (J), Donald E. Sykes (M).

Dayton Section: Leslie V. Anderson (M), John David Elam (J), James Alan Finfrock (J), Robert Thomas Harnsberger (J), Paul Eugene Pritchard (M), Robert James Simons (A), John N. Snodgrass (J), Leo S. Sullivan, Jr. (M).

Detroit Section: Dale Clarence Adams (A), Joseph Gerald Bishop (A), Richard Ludwig Branstner (M), Paul E. Braun (M), T. Michael Brogan (J), Raynard Edwin Brooks (M), Charles George Crocker (M), Thomas Roger Danielson (J), James Dillon (A), Robert Evans (A), Robert William Gray (J), Carl Victor Hajek (J), Scott David Harvey (M), Ralph Kenneth Hillquist (J), Robert Haynes Knapp (M), Donald Walter Kroll (J), Lawrence Wallace Lang (J), Richard Clemens Lins (J), Robert Loel Maloney (J), John Thomas McPherson (J), Richard Frank Moons (A), Michael C. Myal (M), Gary Osterbeck (A), David Jackson Payne (J), Albert Lawrence Schaller (J), Lee J. Seymour (M), Albert Eugene Sickinger (J).

Fort Wayne Section: Robert Lee Dowler (J).

Indiana Section: Louis Miller Brubaker (A), Dale Richard Chambliss (J), Rex Hoppes (J), Donald Gene Slane (J), Clark Estill Sloan, Jr. (M).

Kansas City Section: Hugh Irvin Myers (J).

continued on p. 142

Have you checked carbon & graphite's MANY

"MECHANICAL ADVANTAGES" LATELY?

for High Temperature Work—As bearings or seal rings, several specially-formulated Stackpole grades provide long life and low friction up to 1200°F—temperatures where more costly and exotic materials often fail.

for High-Speed, Unlubricated Uses—In terms of life, maximum speed, and low friction, Stackpole carbon & graphite offer many performance dividends over even more costly self-lubricating bearing and seal ring materials.

Handling Chemicals & Gases—Inert Stackpole carbon & graphite resist attack in all but the most highly oxidizing atmospheres at normal temperatures.

Under Thermal Shock—Stackpole carbon and graphite materials will not spall, crack, melt or seize in difficult refractory applications.

STACKPOLE

Stackpole Carbon Company, St. Marys, Pennsylvania

GRAPHITE BEARINGS & SEAL RINGS • ROCKET NOZZLES • PUMP VANES • VOLTAGE REGULATOR DISCS • GRAPHITE HEATING ELEMENTS • CHEMICAL ANODES • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT • ELECTRICAL CONTACTS • CERAMIC MAGNETS • FERRITE CORES FIXED & VARIABLE COMPOSITION RESISTORS • SLIDES SWITCHES • and many others.

New Members Qualified

continued

Metropolitan Section: John Michael Csady (J), Howard Paul Cutson (A), Robert Norman Farkas (J), Charles Teh-ching Hsu (J), Sven Arne Jones (M), Kazimieras Kizlauskas (J), Leonard Howard Lustbader (J), William E. McTurk (M), Salvatore Negri (J), Michael Joseph Ostrelich (J), Leonard N. Sperber (J), Wallace B. Spielman (A), Curtis M. Stendahl (M), Thomas Grandison Tousey (M), Jeffrey Allan Waldmann (J).

Mid-Michigan Section: Earl Charles Boitel, Jr. (M), James Marquis Lorang (M), Joseph Leo Pohl (A), Leslie L. Shafer (A).

Milwaukee Section: Donald John Huhn (M), Robert Max Kahlow (A), Harlan D. Kuester (M), Rodney Anthony LeMense (J), John Paul Stoltenberg (J).

Mohawk-Hudson Section: James Bromley (A).

Montreal Section: Philip Surtees Hutchinson (A), Donat A. Martinoli (J), Fernand Tetreault (J).

New England Section: George Alfred Biron (A), Edward J. Splaine (M).

Northern California Section: William Henry Hoffman (A), Robert Ian McClure (M).

Northwest Section: Richard Edwin Gregg (J), Alexander Severo March (J).

Ontario Section: Robert Lynn Curtis (J), William Glen Fouse (A), Jack Edward Hollands (M), Harold William Jackman (J), Charles Edward Kellner (J), William Walter Peel (J), Dusan Tosic (A).

Oregon Section: Ronald Clare Householder (J).

Philadelphia Section: Louis Peter Caira (J), Joseph Vito Cresko (J), Gerald Ginsberg (J), George R. Harrington (M), George W. Leck, III (J).

Pittsburgh Section: Ronald Andrew Lichalk (J), Robert Charles Swagler (M).

St. Louis Section: Edgar Bertel (A).

Salk Lake City Group: William Kieth Burke (J).

Southern California Section: Donald Friedman (M), Ronald Robert Mealhow (J), Stanley E. Phillips (A), E. S. Quilter (M), Raymond Charles Rogers (A), George Gustav Wald (M).

Syracuse Section: Walter Clayton Dette (J), Robert Frederick Uhl (J).

Texas Section: Jimmy Hill Blake (J), Grady Gilder, Jr. (M).

Texas Gulf Coast Section: Don Michael Batey (J), James Albertson Cowan, Jr. (J), Walter Wendell Kroupa (J), William Lee Linkenhoger (M), Joe F. VanMeter (A).

Twin City Section: Douglas D. Dankel (M), Dr. Richard Carl Gaard (A).

Washington Section: Nelson M. Cook,

continued on p. 145

a fel-pro gasket
progress report

WINS OEM approval!

Now adopted for one or more applications by leading car factories and manufacturers of trucks, diesel engines, farm tractors, etc.

REASONS: EXCEPTIONAL DIMENSIONAL STABILITY, CONFORMABILITY, SEALING ABILITY, GREATER RESISTANCE TO HIGH PRESSURES AND TEMPERATURES, AND MANY OTHERS.

new FEL-CoPRENE®

the new rubber gasket for cylinder head covers, crankcase and automatic transmission oil pans, etc.

Fel-CoPrene is being used increasingly for O.E.M. Proving ground and laboratory tests, backed by several years of astonishing results on millions of cars, prove beyond doubt Fel-CoPrene is a most superior sealing material. It solves leakage problems, eliminates costly returns and is unaffected by oils and mild solvents.

Fel-CoPrene is an exclusive rubber formula developed by Fel-Pro in cooperation with leading car factories. Its exceptional dimensional stability eliminates those annoying problems of fit. Even after months of storage, Fel-CoPrene does not break . . . become brittle . . . lose resiliency . . . or change its size. It will not stick or tear even after prolonged high-temperature operation—comes off cleanly in one piece.

For complete details, specific performance statistics and cost data write FELT PRODUCTS MFG. CO., Skokie, Illinois. In Detroit: 19932 Livernois Ave. Phone: UNiversity 2-3522.

FEL-PRO gaskets

gasket specialists

since 1918

Copyright Felt Products Mfg. Co. 1961 R-237-OE

THE MOST ECONOMICAL WAY FROM OFFICE TO AIRPORT IS THROUGH STROMBERG

Stromberg® carburetors' built-in economy is just the ticket for "on-the-go" businessmen. In both stop-and-start and highway driving, Stromberg delivers the kind of gas-saving performance these car owners look for.

This economy was proved in the 1961 Pure Oil trials at Daytona Beach, where Stromberg carburetors helped Studebaker Larks finish first and second in the 17-car Class IV race.

Stromberg is a product of more than 40 years' Bendix experience in fuel system designs. It can help boost your engine's economy and dependability. Eclipse Machine Division, Elmira, New York.

Export Sales and Service: Bendix International, 205 E. 42nd St., New York 17, N.Y.

Bendix-Elmira

THE Bendix CORPORATION

New Members Qualified

continued

Jr. (J), Charles James Gauthier (J), Gerald E. Gaylord (J), William W. Sullivan (A).

Western Michigan Section: Konrad Hugh Marcus (M).

Wichita Section: Haynes Clark (M).

Outside Section Territory: Jesse Anthony Baldwin (M), Jule Joseph Baudhuin (A), Robert Edward Buser (J), Keith Dale Harris (J), Steven D. Huntsman (J), James Stephen McKarns (J), Hilton William Mitchell (J), Lawrie Ray Nichol (J), Walter Hammond Wiley, III (J).

Foreign: Charles Belli (M), Malta; Gavin Frederick Hancock (A), South Australia; Ryoichi Nakagawa (M), Japan; Jiro Tanaka (M), Japan; Koichiro Tanaka (M), Japan; Mineo Yamamoto (M), Japan.

Applications Received

The applications for membership received between August 22, 1961 and September 22, 1961 are listed below.

Atlanta Section: Russel W. Lewis

Buffalo Section: Earl Ralph Fischer, Gerald Nelson Gleiser, Lawrence John Muscarella, John Allen Pfrang

Central-Illinois Section: A. L. Jerome, Richard LeRoy May

Chicago Section: Alfons W. Augustyniak, Robert Paul DeGraff, Calvin Keith Hophan, Robert Sinclair Innes, Leo Robert Kiley, Clifford Wentworth Louthan, Joseph Steven Rohaly, David Irwin Van Blois, Manfred Max Weber, Robert Eugene Williams, Robert Loren Wolfberg, Howard Albert Woodin

Cleveland Section: John Edwin Dick, Jr., Fred Jon Kiener, Kent Williams

Colorado Section: Edward Michael Dobrinsky, Mutsumi Vic Hirose, Thomas Roger Jones

Dayton Section: Vernon Oliver Hoehn, Alfred Orlan Long, Kervyn Duane Mach, David Lewis Mehall, Roger Lee Newsock, Leo Anthony Przybylski, Larry Alan Roberts

Detroit Section: John Donald Anderson, Walter William Austin, Robert James Bargert, Andrew Buffa, Larry Jay Burgess, John Julius Cale, Jr., Donnell Ward Connors, Rodger Karl Faul, Hubert, Dale Federer, Dick Allen Glass, Ernesto Augusto Groskopf, Robert William Harris, Fred Eugene Harwood, Stephen Joseph Haydock, Stuart Wilkinson Hisle, Billy Haegen Howell, Philip Henry Hutchinson, Albert John Jehle, Jr., David W. Johnson,

continued on p. 146

"Thousands of 'O' rings used without known failure in the field"

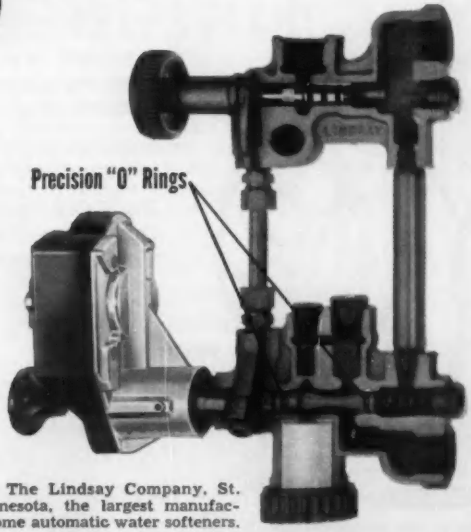
(Another manufacturer knows there's no substitute for reliability.)

"O" Ring Compound No. 1218 was developed by Precision for a leading manufacturer* of automatic water softeners.

The success of the "O" ring in service was predetermined by exhaustive Precision development research which included testing against water samples obtained from all parts of the country. "O" Rings from Compound 1218 are now giving reliable service as seals in Diesel and Aeromatic fuels, high performance gas and permanent anti-freeze.

You can be sure of having the *right* "O" ring, made from the *right* compound for your product when you come to Precision. Why not ask for the services of a Precision Engineer today?

Specify Precision—First in quality



*Made for The Lindsay Company, St. Paul, Minnesota, the largest manufacturer of home automatic water softeners.

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialist

3110 Oakridge Drive, Dayton 17, Ohio Canadian plant at: Ste. Thérèse de Blainville, Québec

Applications Received

continued

Kenneth Thomas Kitchin, Alfred S. Kress, Richard G. Marshall, Nelson Martin Mercer, Jr., Stuart Robert Monroe, Jack R. Phipps, Bernard Henry Ris, Schuyler D. Rogers, Henry Frank Schebor, Lynn Alfred Townsend, Eric Von Valtier, Frank J. Voss.

Fort Wayne Section: Tommy Joe Bedwell, James Richard Buxton, Richard Louis Hollar, Ramchandra L. Patel, Gerald I. Solsrud, Jack Leroy Stark

Indiana Section: Richard Dale Campbell, Roger R. Loefgren, Raymond J. Maci

Kansas City Section: Alvin W. Acker Alan Buchan, Clarence Burnie Hiett, Jr., Harold Joseph McClain

Metropolitan Section: Frank Vincent Baffa, William H. Dawson, Ronald Paul Horn, Emil Paul Knapp, Walter Leon Kouyoumjian, Ralphe Manjarrez, Kenneth Russell Rinehart, Joseph Henry Turner

Mid-Continent Section: Paul Whit Henderson, Kenneth Fountain Whatley

Mid-Michigan Section: Dale Jay Drayton, Hans Engelhardt

Milwaukee Section: Allen Fred Radtke, Robert Joseph Scholz, William P. Schlecht, Wilbur L. Slaymaker, Paul Peter Spanier, James Harry Walkowiak

Montreal Section: Pierre Gadbois

Northern California Section: Marion Eugene Ford, Romeo W. Gouley, Donald W. Houser, Marshall W. Woodson

Northwest Section: Robert Henderson Allen, Jr., Gordon Leight Borst, John Hamil Gray, Jr., Michael L. Lasalle, Willie Frank Page, Orville Arthur Roupe, George Edward Walker, Jr.

Ontario Section: David George Billes, Lynn Anthony Bottoms, William Robert John Ellwood, Regnerus Bonifatius Hettinga, John Aldus King, Robert Neale McKenney, Karl Edwin Scott, W. Ross Smith, Oliver Harold Vogt

Oregon Section: Darryl Delbert Devnich, Harlan David McKay

Philadelphia Section: Shelley Curry, John James Jacoby

Pittsburgh Section: James Lewis Brandt, Ronald Wallace Frost, Richard Anthony Mancuso, Nicholas Pamphilis

St. Louis Section: Ralph Matthew Tyson

Salt Lake Group: Harry Vincent Chapman

San Diego Section: Harley Donald Brown

Southern California Section: Donald Howare Blakeley, Bill Joseph Castenholz, James Taylor Hulbert, Leoroy Huntington, Billy Ray Lawver, Peter J. Olson, Paul Robert Schoenhardt, Forrest Robert Tucker, Milton Joseph Webb

Southern New England Section: Laurence Morton Brady, Bruce Fulton Jones, Raymond Edgar Spears

Syracuse Section: Patrick Hillier, Paul W. Ing, Norman H. Smith

Texas Section: William James Brown

Twin City Section: William B. Lagerquist, John Charles Nelson

Washington Section: Joel Mack Jordan

Western Michigan Section: Thomas Stephen Dierda, David Karel Veenstra

Outside of Section Territory: William Michael Cardigan, Terrance Edward Donlin, Eugene LaMoyne Eckfield, Ronald Barry Finlay, Robert Forget, Thomas William Freiburger, Dale Eugene Good, Norman Howell Milstead, David L. Prescott, Lawrence Romanchuk, Verne Mehner Spangenberg, William Alvin Wahl

Foreign: Jaffery Agha Hasan, Pakistan; Fernando Caballero, Colombia; Lascelles Anthony Chen-Young, Jamaica; Shelton Ranjit Fernando, Ceylon; Kyuya Koito, Japan; George Raymond McLaren, England; Captain P. M. Mukherji, India; Krishnan Ramaswami, India; Ramesh Chandra Rath, India; Tibor Scheimann, South Africa; Mallikarjun Nagappa Shatgar, India; Chandrakant J. Talsania, India.

What WI-COoperation means to the design engineer!

- A prestige line of ignition, made to the highest quality standards . . . 100% inspected and guaranteed.
- A team of trained representatives in the field, augmented by a well organized service department at the factory.
- A modern laboratory, staffed by engineers experienced in solving technical problems of ignition.
- A delivery policy geared to meet regular and emergency schedules.
- Over 6,000 WICO dealers in the U.S. and Canada (as well as foreign countries) . . . ready to supply after-market parts.

PRODUCTS:

• INDUSTRIAL ENGINE ACCESSORIES
• MAGNETOS • BATTERIES
• ALTERNATORS
• BATTERY IGNITION SYSTEMS

WICO
Member of Automotive Electric Association

Write for complete literature

WICO IGNITION DIVISION

Dept. SJ-5, West Springfield, Massachusetts, U.S.A.

WICO IGNITION | GLOBE BATTERY | Centralab ELECTRONICS

DIVISIONS OF GLOBE-UNION INC.

DEPENDABLE IGNITION SINCE 1897

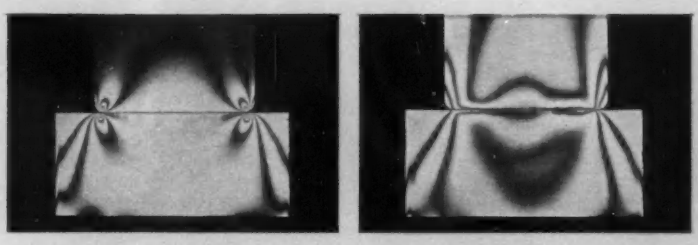
CROPS OR POLES...BEARING MUSCLE HELPS PLANT 'EM BOTH!

From plowing and seeding to digging post holes, the farmer *depends* on his tractor and implements for plenty of muscle, when and where needed. It's no wonder he looks especially for stamina and proven dependability in the new equipment he buys. For this reason, farm equipment manufacturers select vital components with great care. Leading tractor and implement makers, for instance, use Bower Roller Bearings as original equipment. Bower's original contributions to advanced bearing design, plus painstaking quality control, reduce bearing maintenance and failure to a practical minimum . . . help manufacturers keep their equipment rolling. For *your* bearing requirements, Bower provides a complete line of tapered, straight and journal roller bearings. Bower Roller Bearing Division, Detroit 14, Michigan.

BOWER
ROLLER BEARINGS

tapered cylindrical journal

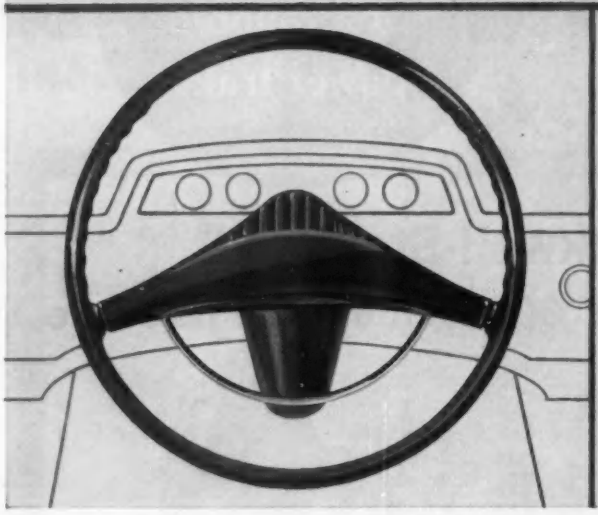
DIVISION OF
FEDERAL-MOGUL-BOWER
BEARINGS, INC.



Roller bearing life and capacity are linked to stress distribution. Photoelastic studies indicate both magnitude and distribution of stress. Identical loads show dangerous edge-load stress build-up in conventional roller (left) . . . Bower "Profiled" roller (right) eliminates points of excessive stress concentration. Result—improved load-carrying capacity, increased life.

if she takes pride
in her home—
give her a kitchen
of stainless steel
McLOUTH
STAINLESS
STEEL—the spotless
metal for homes and
home products.
McLouth Steel Corporation
Detroit 17, Michigan

What's News in Plastics...



Specify Escon® polypropylene for low odor pick-up

Escon has no taste or odor of its own and is highly resistant to stain and odor pick-up. This important property makes Escon an excellent choice for food storage containers and packaging, compacts and lipstick cases—even automobile steering wheels.

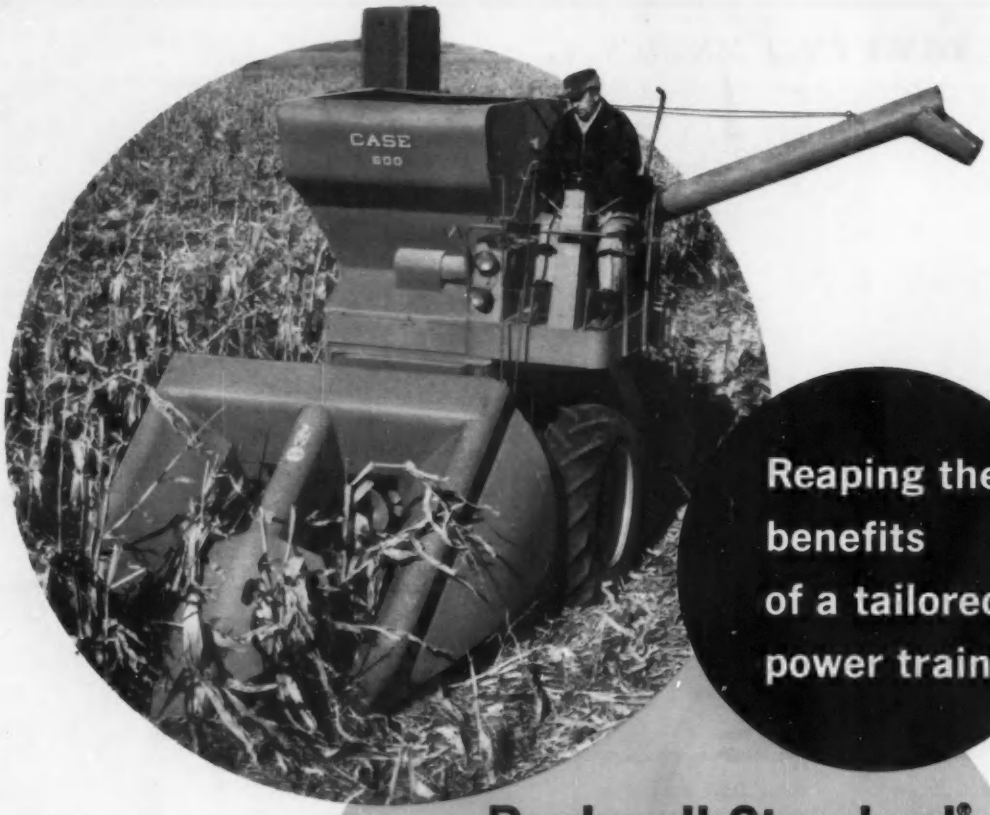
Escon polypropylene offers manufacturers a *balanced* combination of properties for high-speed, profitable production—including resistance to dynamic fatigue, high strength, chemical and abrasion resistance, and many more. Expert technical assistance is always available. For full details, write to Enjay, 15 West 51st Street, New York 19, N. Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

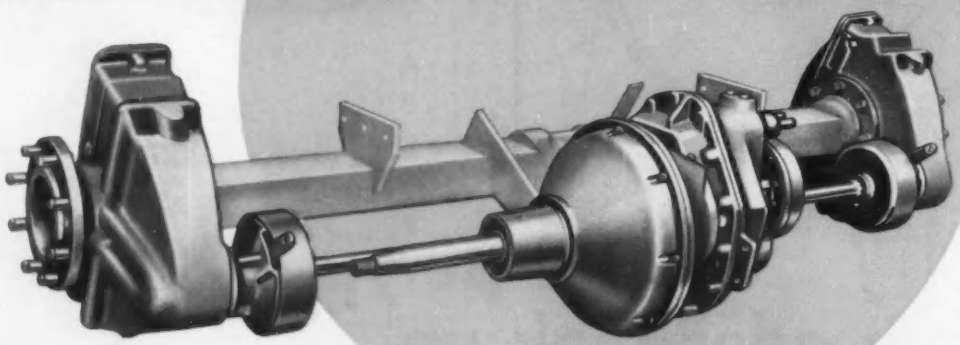
ENJAY



Reaping the benefits of a tailored power train

Rockwell-Standard®

Custom Drive Helps New Case "600" Combine Do Its Chores!



J. I. Case Company engineers designed the new "600" Combine with three significant advantages—big capacity, extra maneuverability and unexcelled versatility! More than ever, here is a combine engineered and built to do a remarkable job of meeting the needs of all crops and harvesting conditions.

To make sure this equipment does all its jobs well, a custom-made drive was needed. And because of their proven performance on other J. I. Case vehicle needs, Rockwell-Standard engineers were called in to work with Case planners and designers. Result of this cooperative effort was the new Rockwell-Standard TA-251 Axle. In every test to date, this specially designed driving axle has proven that it will give long, efficient, productive service—and take all the rugged usage for which the Case "600" was built.

Rockwell-Standard is the acknowledged leader in developing axles for all types of specialized vehicles. Whatever problems you have in designing and building self-propelled drives, consult Rockwell-Standard. Their specialized experience is industry-wide. It costs you nothing—and will undoubtedly offer you substantial savings in both time and money.

Another Product of ..

ROCKWELL-STANDARD CORPORATION

Transmission and Axle Division, Detroit 32, Michigan

BESTWALL INDUSTRIAL GYPSUM PLASTERS

PHYSICAL PROPERTIES	Pouring Consistency (PC)	Setting Time Gillmore Needle Initial	Setting Time Gillmore Needle Final	Setting Expansion % Percent	Setting Expansion Inch Per Inch	Compressive Strength 1 Hour After Set P.S.I.	Compressive Strength Dry P.S.I
Sunflower	68-70	38-50 min.	50-65 min.	.17 to .19	.0017 - .0019	1000-1100	2100-2400
Sunflower L.E.	68-70	38-50 min.	50-65 min.	.09 to .11	.0009 - .0011	1000-1100	2100-2400
Densite K-12	36-37	25-35 min.	35-45 min.	.035 to .045	.00035 - .00045	2500-3000	5600-6300
Densite K-17	43-45	20-30 min.	30-40 min.	.06 to .07	.0006 - .0007	2000-2500	5000-6000
Densite K-20	41-43	30-40 min.	40-50 min.	1.0 to 1.2	.01 - .012	900-1200	2200-2700
Densite K-25	44-46	30-40 min.	40-50 min.	.04 to .05	.0004 - .0005	1900-2400	4800-5800
Tooling Densite	38-40	25-35 min.	35-45 min.	.045 to .060	.00045 - .0006	2500-3000	5600-6300
Breakaway	110-120	40-50 min.	50-60 min.	.09 to .11	.0009 - .0011	60-80	250-350

INDUSTRIAL PLASTERS FOR THE TOOLING INDUSTRY

from the NEW BLUE RAPIDS PLANT

Material	Principal Use	Description
	LOW EXPANSION DENSITES	
Densite K-12	Duplicator Models	Lowest expansion provides great accuracy, high strength and hardness
Tooling Densite	Duplicator Models, Splash Castings, Screeding, Rodding, Loft Template Work	Low expansion; special ingredients insure longest working time of any tooling plaster of comparable set
Densite K-17	Pattern & Model Making	A low expansion, high strength plaster used extensively for Keller patterns
Densite K-25	Pattern & Model Making	Same general characteristics as K-17 but is more plastic and builds up better on splash castings than any other high strength plaster
	HIGH EXPANSION DENSITE	
Densite K-20	Pattern Making	Gives necessary high expansion to patterns when necessary to compensate for shrinkage of aluminum or zinc alloy metals as Kirksite, etc.
	REGULAR MOLDING PLASTER	
Sunflower Molding L.E.	Temporary Patterns Waste Molds	A general purpose tooling plaster. Has lowest expansion of all molding plasters on market. Lower cost than Densites.
	SPECIALTY	
Breakaway	Expendable Mandrels For Forming Plastic Casts	A premium product for formation of irregular ducts and tubes. Immersion in hot water softens the plaster core and permits easy removal. Colored buff for easy identification.

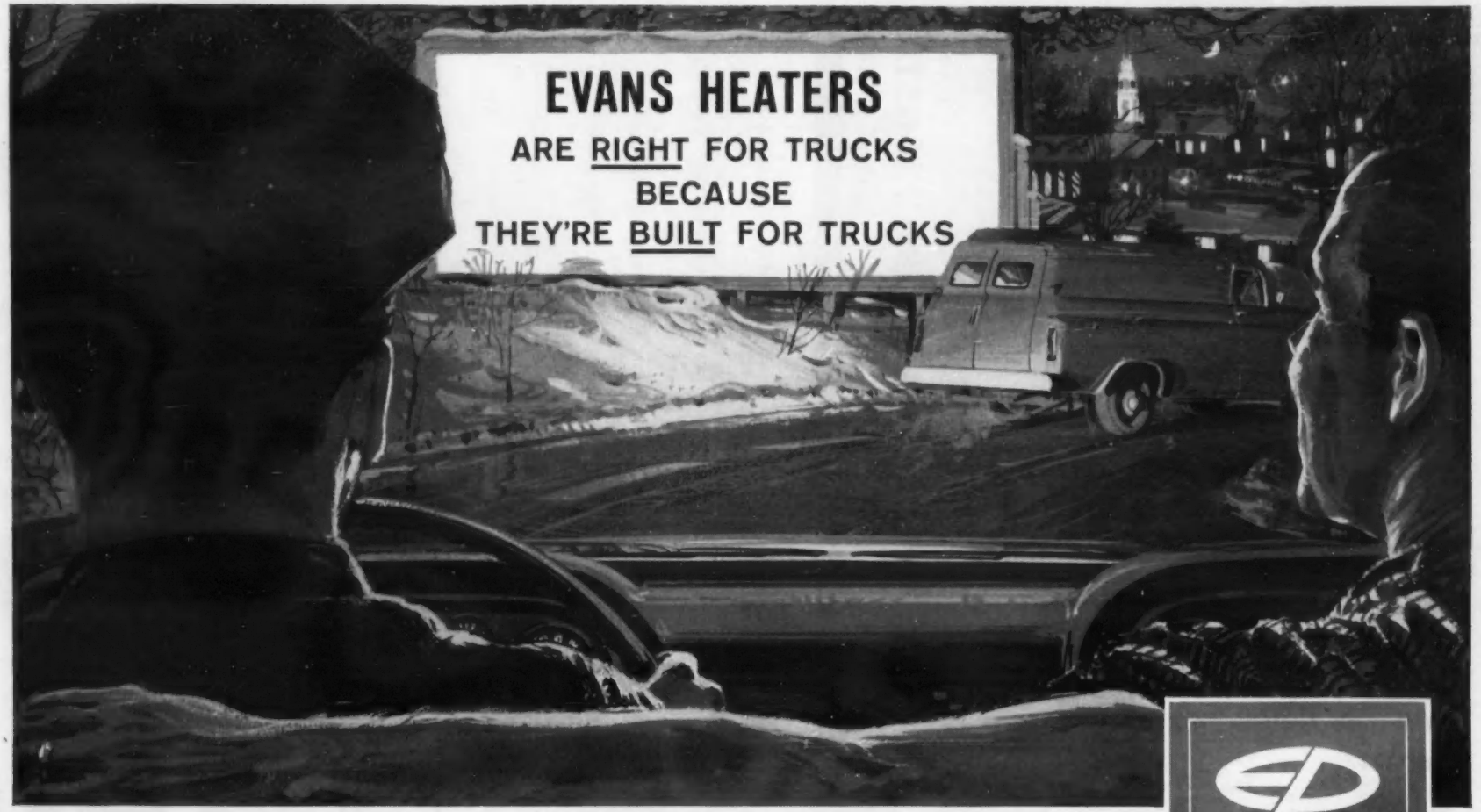
INDUSTRIAL BESTWALL GYPSUM PRODUCTS

BESTWALL GYPSUM COMPANY

Ardmore, Pennsylvania

Plants and offices throughout the United States

FIELD EXPERIENCE + CUSTOMER NEEDS + MODERN RESEARCH + MODERN PLANTS = FULL LINE OF BESTWALL INDUSTRIAL PRODUCTS



Evans heaters are durable, dependable, rugged—*built for trucks!* They're tailored to truck manufacturer specifications, custom-engineered to provide the *right* BTU rating and heat distribution *for your specific truck models.* They're designed for quick, easy maintenance.

Product quality has made Evans the largest manufacturer of heavy-duty truck heaters. Evans' heater production is backed by 25 years of engineering experience, rigorous tests and assembly-line inspections. And backing each individual Evans heater is a one-year/50,000-mile warranty.

Our engineers are ready to work with yours to design an Evans heater to meet your requirements. Write Evans Products Company, Dept. Z-11, Plymouth, Mich.

Hallmark of Quality Products

EVANS PRODUCTS COMPANY
PLYMOUTH, MICHIGAN
HEATING AND VENTILATING DIVISION

REGIONAL REPRESENTATIVES: Chicago, R. A. Lennox • Detroit, Chas. F. Murray Sales Co. • Allentown, Pa., P. R. Weidner

Morse quality timing chains: best under the sun for more than fifty-six years

There are good reasons why Morse timing chains are original equipment in over 76% of all American cars. For more than 56 years they have provided perfect valve timing—like the timing of a fine watch, and every bit as quiet. Morse quality control is of the highest order, from steel purchased in special mill runs, to laboratory hardness tests, to demagnetization. As a finishing touch timing chains are even vacuum-cleaned to remove foreign particles which might affect long life. What better reasons could there be for anyone to specify Morse? For further information, write: Morse Chain Company, Dept. 12-111, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Ill. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ont.

MORSE

A BORG·WARNER INDUSTRY

BW

for over fifty years

In 1908—the CHICAGO FIRE DEPT. —then as now—was up-to-the-minute with Waukesha Engine powered equipment.

fast · rugged · powerful

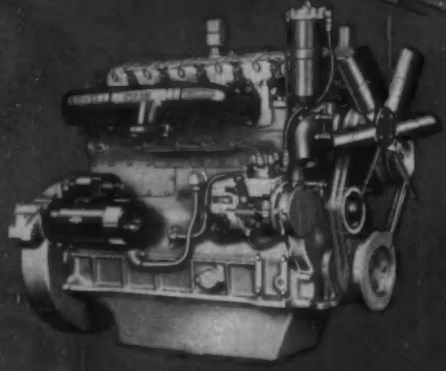
WAUKESHA *transport* ENGINES

Where the pay-off is on pay-load — in fast cross country service . . . off the highway . . . or extra heavy duty hauling — you'll make more miles and cut costs, too, with these modern Waukesha truckers' engines. Designed to put out the power, Waukeshas pull-and-pay day after day without faltering or breakdown. Up to 400 horsepower.

Send for Bulletins

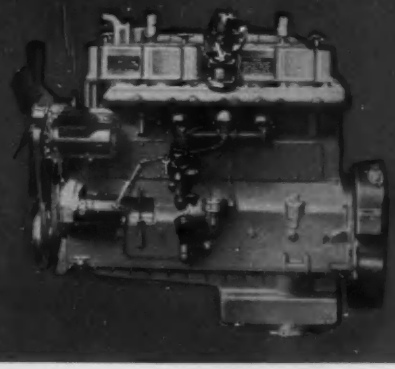
WAUKESHA MOTOR COMPANY • WAUKESHA, WIS.
New York • Tulsa • Huntington Park, Calif.

529



135-DKB Diesel, 4¼ x 5 inch bore and stroke, 426 cu. in. displacement, to 145 hp.

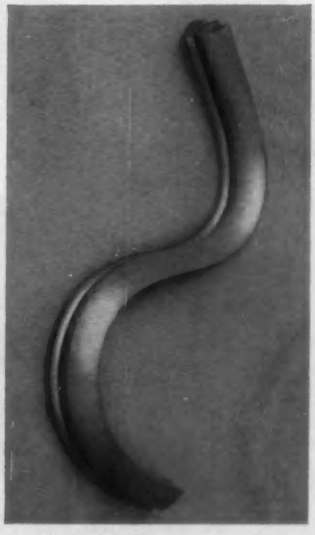
145-GZ Gasoline, 5⅜ x 6 inch bore and stroke, 817 cu. in. displacement, to 300 hp.



COMPLEX CROSS SECTIONS

WEATHER AND OZONE RESISTANCE

LOW WATER ABSORPTION



TIGHT RADII EASILY TURNED

EXTRUDED CLOSED CELL

NEOPRENE IMPROVES BODY SEALING

Only neoprene closed cell extrusions offer all these proven advantages as a body seal:

Excellent resistance to weather, ozone, aging, sun and oil.

Low water absorption; due to the characteristic closed cell structure, water absorption is held to a minimum . . . eliminates need for a veneer or coating.

Available in a variety of complex cross sections . . . adaptable to any closure design.

Tight radii easily turned without wrinkling.

Extruded closed cell neoprene is already being used effectively as a door and deck lid seal and as a hood lacing. Potential applications include roof rail seals, windlace and other body gasketing applications.

For more information on this new approach to body seal design, write for your free copy of our helpful brochure, EXTRUDED CLOSED CELL NEOPRENE.

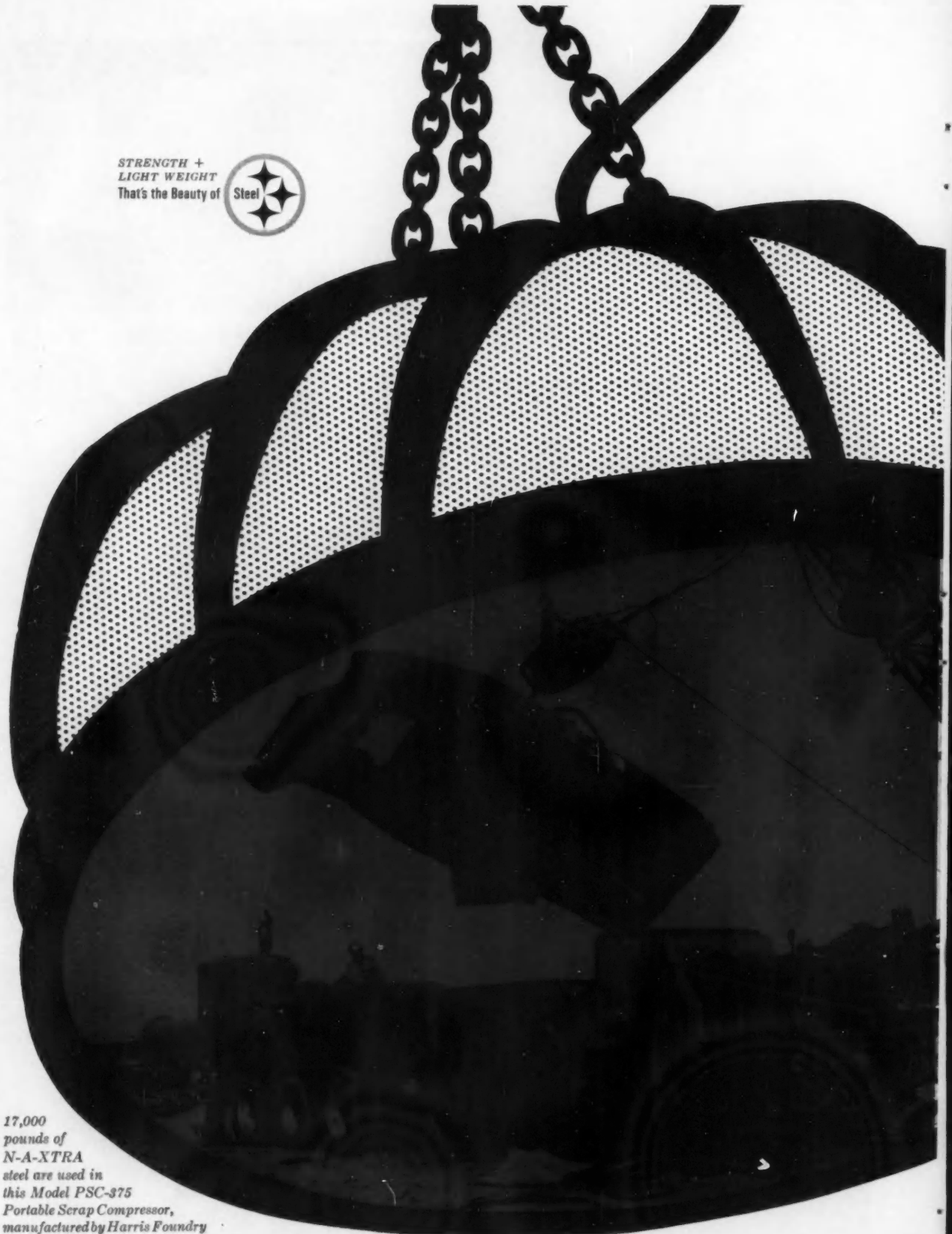
E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department SAE-11, Wilmington 98, Delaware.

DU PONT
REG. U. S. PAT. OFF.

NEOPRENE
SYNTHETIC RUBBER

Better Things for Better Living . . . *through Chemistry*

STRENGTH +
LIGHT WEIGHT
That's the Beauty of Steel



17,000 pounds of N-A-XTRA steel are used in this Model PSC-375 Portable Scrap Compressor, manufactured by Harris Foundry & Machine Co., Cordele, Georgia

STRENGTH + LIGHT WEIGHT OF

N-A-XTRA

HIGH-STRENGTH STEEL SOLVES PORTABLE SCRAP COMPRESSOR PROBLEM

This unique portable scrap compressor can squeeze an entire auto body into a 21″ x 36″ x 24″ bale of 20% dense steel scrap, using a ram pressure of 375 tons. Designed to be hauled from job to job by a conventional truck-tractor, it goes to work in outlying wrecking yards, compressing bulky scrap into marketable bales that can be shipped economically.

Because it must be moved over the highway and meet established load limits, a pressing problem in designing the PSC-375 was weight. Mild carbon steel with the required strength would weigh too much. N-A-XTRA high-strength steel solved the problem. It fully met all strength and fabrication requirements, yet kept total unit weight within acceptable limits for portability.

Portability may not be the controlling factor in your product—but the same steel that solved this problem is the one to remember when only the strongest steel will do. Pound for pound, N-A-XTRA steels are nearly three times stronger than mild carbon steel. Rugged conditions, heavy loads and weight-saving construction—in such applications, for example, as heavy machinery and pressure vessels—are challenges that N-A-XTRA is designed to meet.

With excellent weldability, formability, and toughness even at subnormal temperatures, N-A-XTRA low carbon, extra strength alloy steels give superior results with conventional fabricating methods, including cold forming, gas cutting, shearing and machining. N-A-XTRA high-strength steels are available in four levels of minimum yield strength, from 80,000 to 110,000 psi, and in sizes ranging from ⅛″ to 1″ thick, up to 72″ wide and up to 35′ long. For further information, write Product Development, Dept. SAE-12, Great Lakes Steel Corp., Detroit 29, Michigan.

DESIGN NOTE: Model PSC-375, Portable Scrap Compressor, uses N-A-XTRA 100 (minimum yield strength, 100,000 psi) in engine and tank mounts, bed and side ribbing, arm housings and end housing. Sizes—¼″, ⅜″, ½″, ¾″ and 1″ thick. Fabrication followed standard gas cutting and welding procedures.

N-A-XTRA HIGH-STRENGTH STEELS

a product of

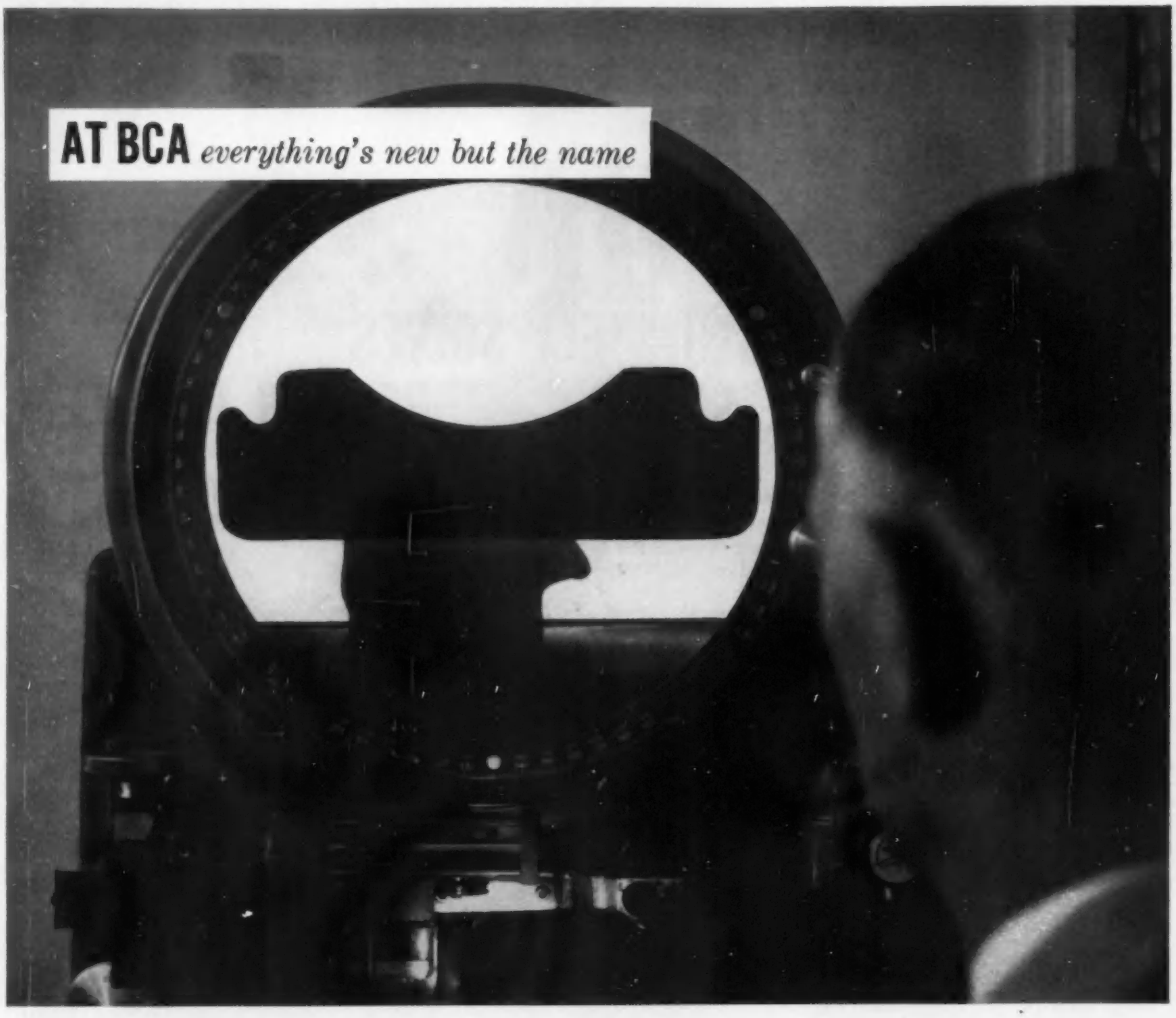
GREAT LAKES STEEL

Detroit 29, Michigan

N-A-XTRA STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

Benedict-Miller, Inc. Lyndhurst, New Jersey	Joseph Demsey Co. Cleveland, Ohio	Ducommun Metals & Supply Co. Los Angeles, California
Interstate Steel Co. Des Plaines, Illinois	Lockhart Iron & Steel Co. Pittsburgh, Pennsylvania	Marsh Steel & Aluminum Co. Kansas City, Missouri
O'Neal Steel, Inc. Birmingham, Alabama	Salt Lake Hardware Co. Salt Lake City, Utah	A. C. Leslie & Company, Ltd. Montreal, Canada

Great Lakes Steel is a Division of **NATIONAL STEEL CORPORATION**



BIG PICTURE—100 TIMES ACTUAL SIZE—

checks ball bearing geometry

BCA engineers take a close, "big" look at the configuration of inner and outer rings of ball bearings with this contour projector. It magnifies profiles up to 100 times actual size—makes possible extremely accurate measurements and control of all geometric characteristics of raceway rings.

This contour projector provides essential information for BCA research in developing new and modified bearing designs. It also evaluates the production performance of precision tools and machine set-ups by checking the profiles of production raceway rings against precise design specifications. This device is only one of many BCA quality control measures that help assure uniformly high ball bearing quality.

New BCA laboratory facilities also include a variety of specially designed testing machines that simulate actual or exaggerated operating conditions. On this equipment, bearings are studied under exact operating conditions of the customer's application . . . and tested to *exceed* his specifications.

BCA ball bearings for original equipment as well as replacement use are made in a complete range of types and sizes. They serve practically every kind of industry . . . automotive, machine tool, construction and agricultural equipment, to name a few. For complete information, for experienced engineering counsel on bearing applications, contact: Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc., Lancaster, Pa.

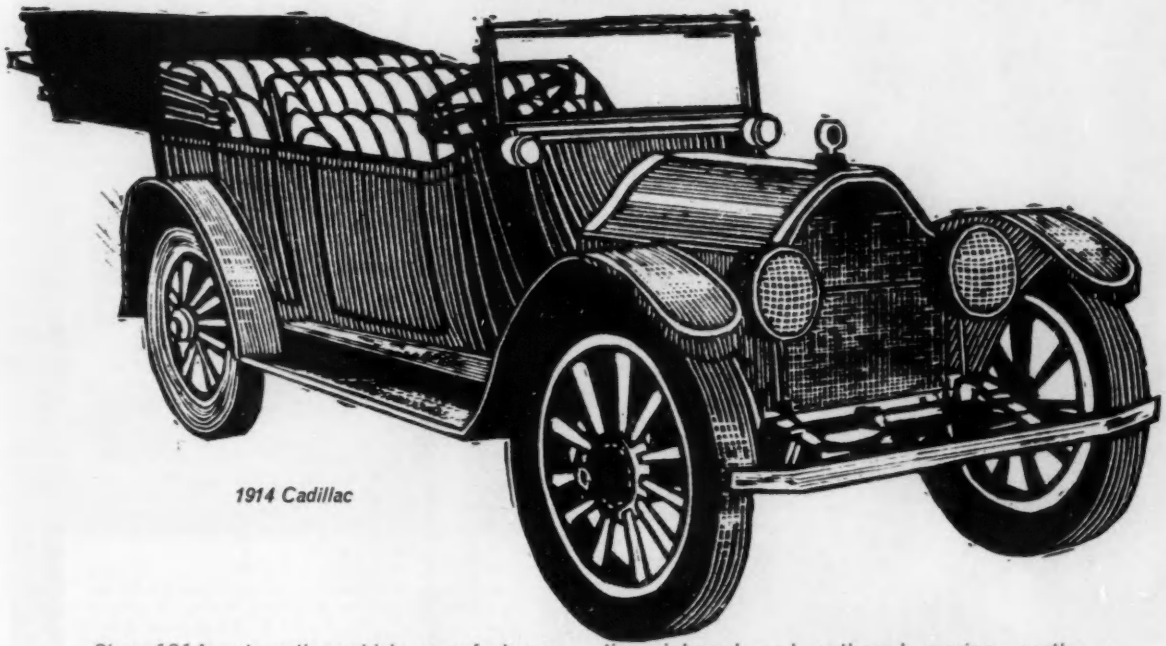
BCA

BEARINGS COMPANY OF AMERICA

ball bearings

DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.

BENDIX... FIRST NAME IN STARTER DRIVES FOR ALMOST 50 YEARS



1914 Cadillac

Since 1914, automotive vehicle manufacturers . . . and their customers . . . have relied on the dependability of Bendix® Starter Drives. Today, they are specified the world over for trouble-free operation and long service. Whatever the internal combustion engine—aircraft, locomotive, inboard and outboard marine, earth movers—you'll find Bendix Starter Drives are first choice. For compact engine designs, Bendix now offers new, positive-engagement Roller Clutch Starter Drives with an over-run feature. Eclipse Machine Division, Elmira, N.Y.

Bendix-Elmira

THE Bendix CORPORATION

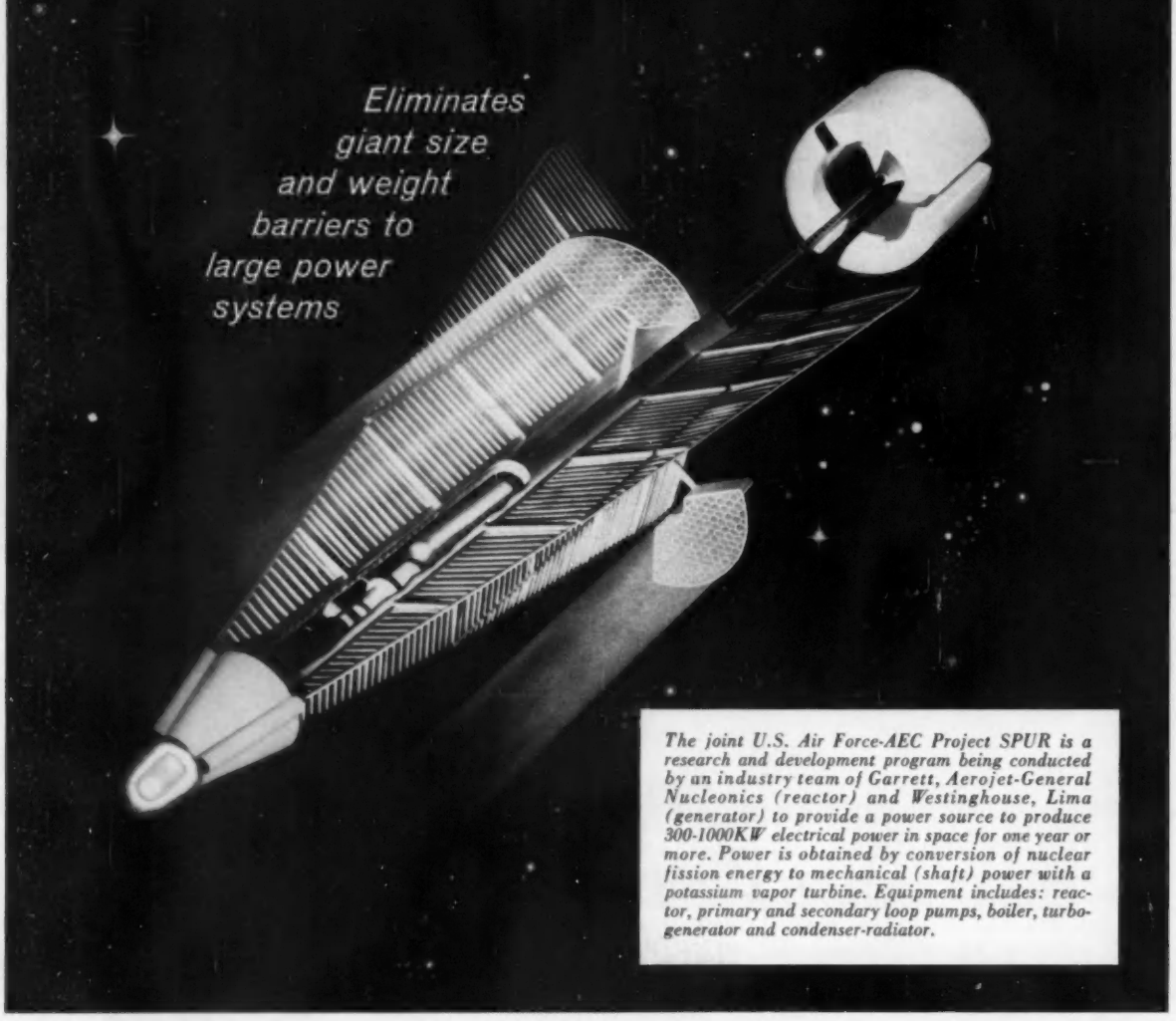
140,000,000 installations are your assurance that Bendix Starter Drives provide better performance

Clutch Drive | Heavy-Duty Spring Type | Positork® | Folo-Thru® | Rubber Folo-Thru® | Roller Clutch

Export Sales and Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

GARRETT-U.S. AIR FORCE 'SPUR'

..one answer to America's future power needs in space



The joint U.S. Air Force-AEC Project SPUR is a research and development program being conducted by an industry team of Garrett, Aerojet-General Nucleonics (reactor) and Westinghouse, Lima (generator) to provide a power source to produce 300-1000KW electrical power in space for one year or more. Power is obtained by conversion of nuclear fission energy to mechanical (shaft) power with a potassium vapor turbine. Equipment includes: reactor, primary and secondary loop pumps, boiler, turbo-generator and condenser-radiator.

Long lead time is essential to the development of large nuclear space power systems. Present methods of power generation would require an impractical heat rejection surface nearly the size of a football field for a power output of one megawatt—power which will be needed for critical space missions already in the planning stage.

Garrett's AiResearch Divisions have now completed the initial SPUR design studies and proved the project's feasibility to supply continuous accessory power and low thrust electrical propulsion in space for long periods of time.

Cutting projected 1 MW power systems to 1/10th the size and 1/5th the weight of present power systems under development will be possible because of SPUR's capability to operate at higher temperatures, thereby sharply reducing the required radiator area.

Garrett has been working with the Air Force and the Atomic Energy Commission on SPUR as the prime contractor for more than one year and has more than five years of experience in space nuclear power development. Also an industry leader in high speed rotating machinery, heat transfer equipment, metallurgy and accessory power systems, the company is developing design solutions for SPUR in these critical component system areas.

THE GARRETT CORPORATION

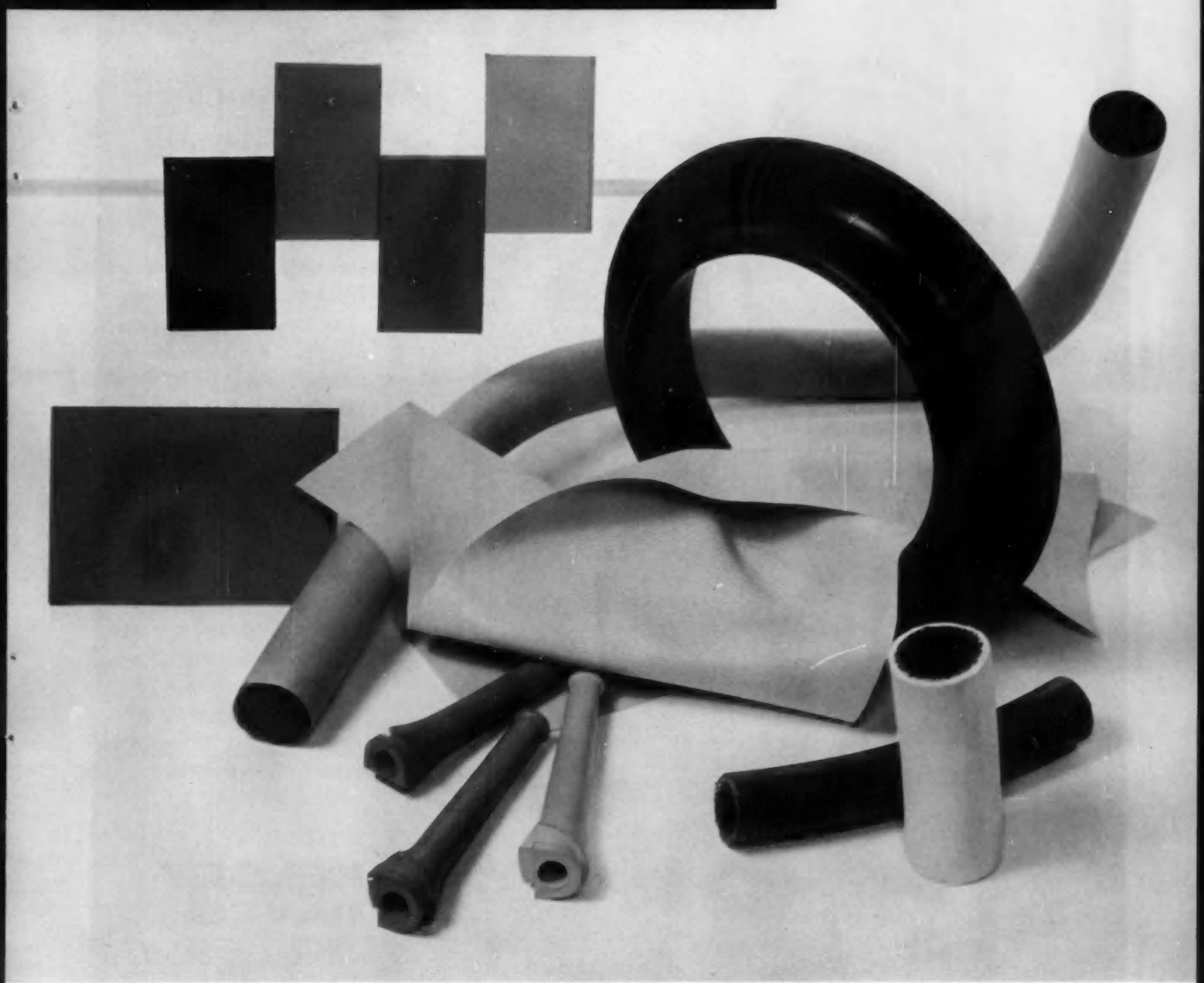
AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems and Components for: AIRCRAFT, MISSILE, SPACECRAFT, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

Naugatuck PARACRIL OZO

THE OIL-RESISTANT, OZONE-RESISTANT NITRILE RUBBER



...tough, oil-proof, weather-proof and **colorful, too!**

The samples above should begin to give you some idea of the endless color possibilities in ozone-resistant rubber products made of new PARACRIL® OZO. Now you can give your product color that *sells*... color that identifies for coding wire and cable jacketing... color that blends or *contrasts*... color that works in a hundred ways. And you can give your product other superior properties, too.

Along with color, new weather-resistant PARACRIL OZO gives you a combination of high abrasion resistance, oil resistance, flex life and other valuable rubber properties far surpassing conventional weather-resistant rubbers.

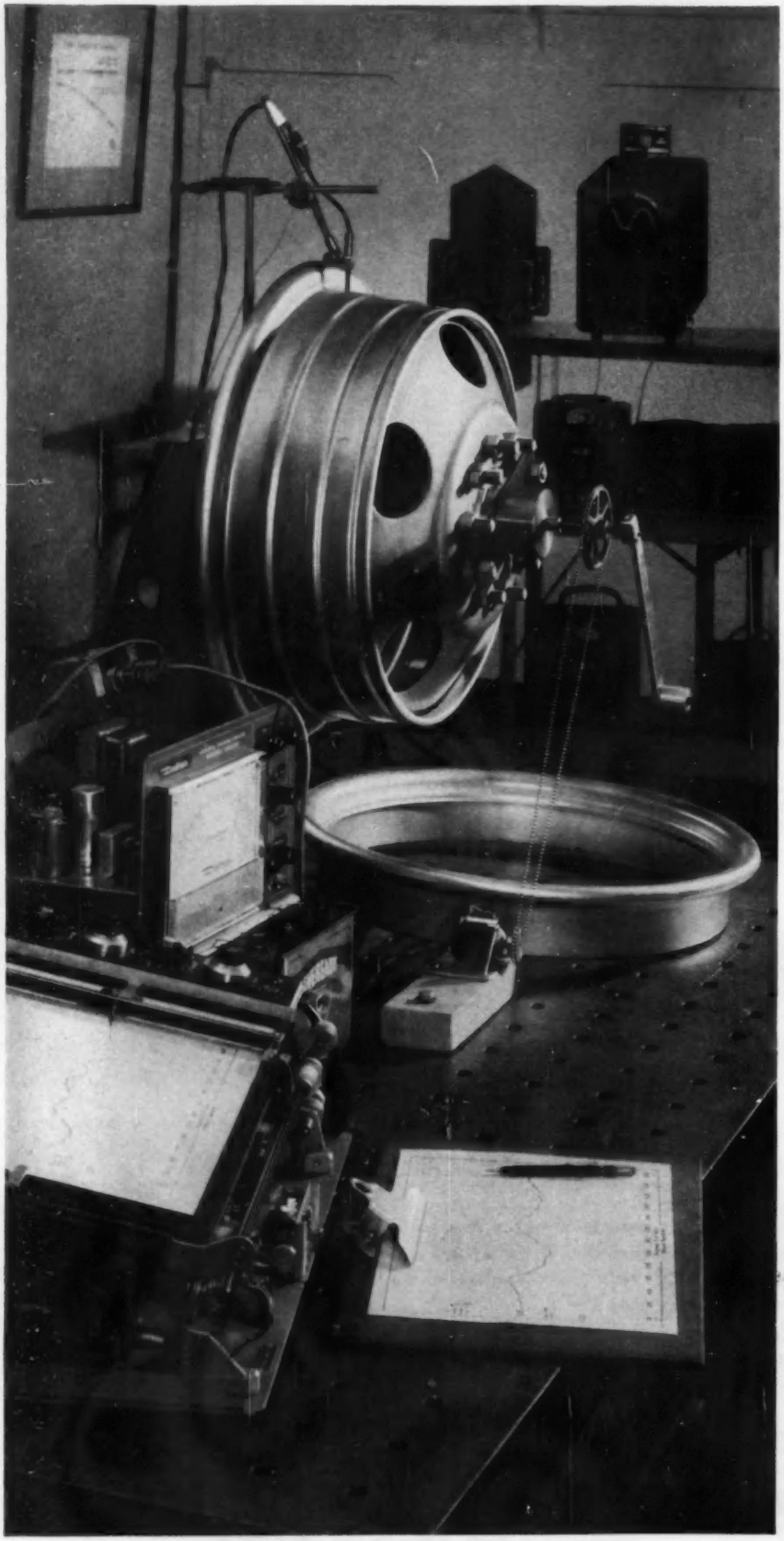
Cast a new eye on the rubber product you make or buy. See the difference color makes. See your Naugatuck Chemical Representative or write the address below for full information on PARACRIL OZO and the advantages it offers.

Naugatuck Chemical

Division of United States Rubber Company Dept. A Elm Street Naugatuck, Connecticut

US RUBBER

Rubber Chemicals · Synthetic Rubber · Plastics · Agricultural Chemicals · Reclaimed Rubber · Latices · CANADA: Naugatuck Chemicals Division, Dominion Rubber Co., Ltd., Elmira, Ontario · CABLE: Rubexport, N.Y.



proved truer running easier on tires

Proved over millions of ton miles, the Kelsey-Hayes three-piece truck wheel provides more uniform tire bead support and uniform stress distribution which reduces rim fatigue! It is quieter and smoother running. And our unique lock ring construction affords fool-proof "blow-off" protection.

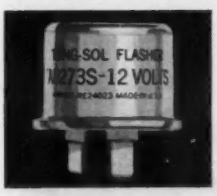
Component dimensional accuracy held to closest tolerances in the industry (here being checked in our lab) and advanced wide-base design are reasons why it is becoming the preferred design for commercial vehicles. Millions are now in service. Kelsey-Hayes Company, General Offices: Romulus, Michigan.

KELSEY HAYES COMPANY

OPERATIONAL PLANTS: Detroit, Jackson and Romulus, Michigan; Los Angeles, California; Philadelphia, Pennsylvania; Springfield, Ohio; Utica, New York; Davenport, Iowa; Rockford, Illinois; Windsor and Woodstock, Ontario, Canada.

K H

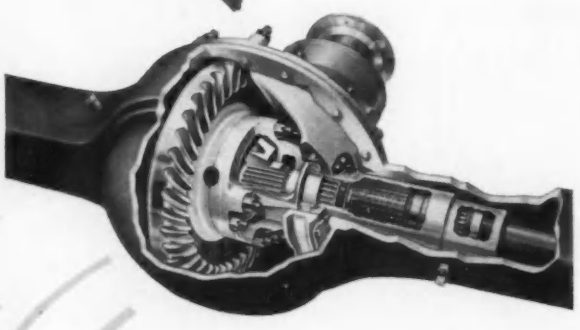
Now available: the only thermal flasher that meets the new S.A.E. specifications



ONLY TUNG-SOL has succeeded in producing a new thermal-type flasher that meets the J590-61 S.A.E. specifications—the most rigid ever written for passenger car application. This ability to meet the ever-higher requirements of the automobile industry is conclusively demonstrated by the fact that Tung-Sol direction signal flashers are used exclusively for initial equipment by all American car manufacturers.

TUNG-SOL®

TUNG-SOL ELECTRIC INC., NEWARK 4, N. J. TWX: NK 193 — HEADLAMPS • MINIATURE LAMPS • FLASHERS



Rockwell-Standard® Traction Equalizer... puts action where there's traction!

The Rockwell-Standard Traction Equalizer provides a substantial increase in tractive effort to the wheel with the best road adhesion. It is effective on a vehicle even if one pair of driving wheels has no traction. Provides safer, surer performance on or off the highway . . . easier control on curves, slippery pavement and soft ground. Eliminates tendency of vehicle to swerve when one wheel suddenly loses traction.

Automatic actuation. Doesn't depend on driver to start it working. Whenever one wheel tends to turn faster than the other, Traction Equalizer starts to work.

Tailored to your needs. With multi-drive axle vehicles, each axle may be equipped with Traction Equalizer units. No matter where your vehicles operate—on or off the highway—the Rockwell-Standard Traction Equalizer gives your vehicles better traction.

Self lubricating. Traction Equalizer automatically picks up standard axle lubricant and works it through unit.

Less maintenance. Normally, Traction Equalizer requires no maintenance between axle overhaul periods. It also cushions impact of heavy loads on tires, shafts and gears.

Another Product of... **ROCKWELL-STANDARD CORPORATION**

Transmission and Axle Division, Detroit 32, Michigan

Norman Shidle's new book

"INSTINCTS IN ACTION"

... is 140 **"FOR SAKE OF ARGUMENT"** pieces selected from those printed in SAE Journal...

Shidle, editor of SAE Journal, says of this collection of his work: "Most of these essays are commentaries on *how* people act; and *why* they act the way they do."

Contents Include

- Individuals Are The Best Organization Men
- Handling People Is Everybody's Job
- It Takes All Kinds
- Understanding Each Other Isn't Easy
- Look At It *This* Way
- Where Are We Going? What Are We After?

SOCIETY OF AUTOMOTIVE ENGINEERS, INC. • 485 Lexington Avenue, New York 17, N. Y.

Please send me_____copy (copies) of Norman Shidle's new book, "Instincts in Action", which contains selected "For Sake of Argument" pieces published in SAE Journal between 1948 and 1961. Price is $4.00 per copy. Quantity prices on request.

Name_____

Address_____

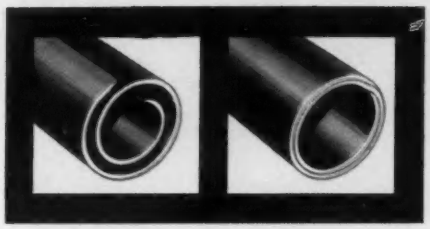
Check enclosed ☐ Coupons enclosed ☐ Bill me ☐

Bundy can mass-fabricate practically anything

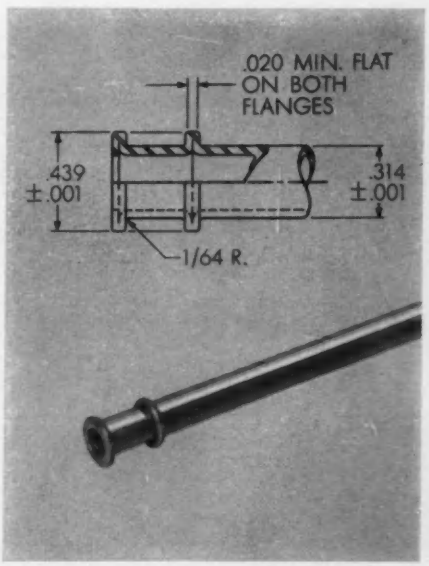
Versatility? Long experience? Bundy has both; and that's why Bundy has no equal in the precision-forming of tubing for the automotive industry. Specialists design Bundy mass-fabrication fixtures and machines for precision at the lowest possible unit cost . . . whether it's a matter of a simple bend or the most complex shape. Quality? You can't beat Bundyweld® steel tubing; standard wall thickness and O.D. are held to +.002″ to −.003″, and it meets Government Specification MIL-T-3520, Type III; ASTM 254; and SAE specifications. When you need tubing, it pays to talk to Bundy first. Call, write, or wire: Bundy Tubing Company, Detroit 14, Mich.

BUNDY TUBING COMPANY • DETROIT 14, MICH. • WINCHESTER, KY. • HOMETOWN, PA.

World's largest producer of small-diameter tubing. Affiliated plants in Australia, Brazil, England, France, Germany, Italy, Japan.

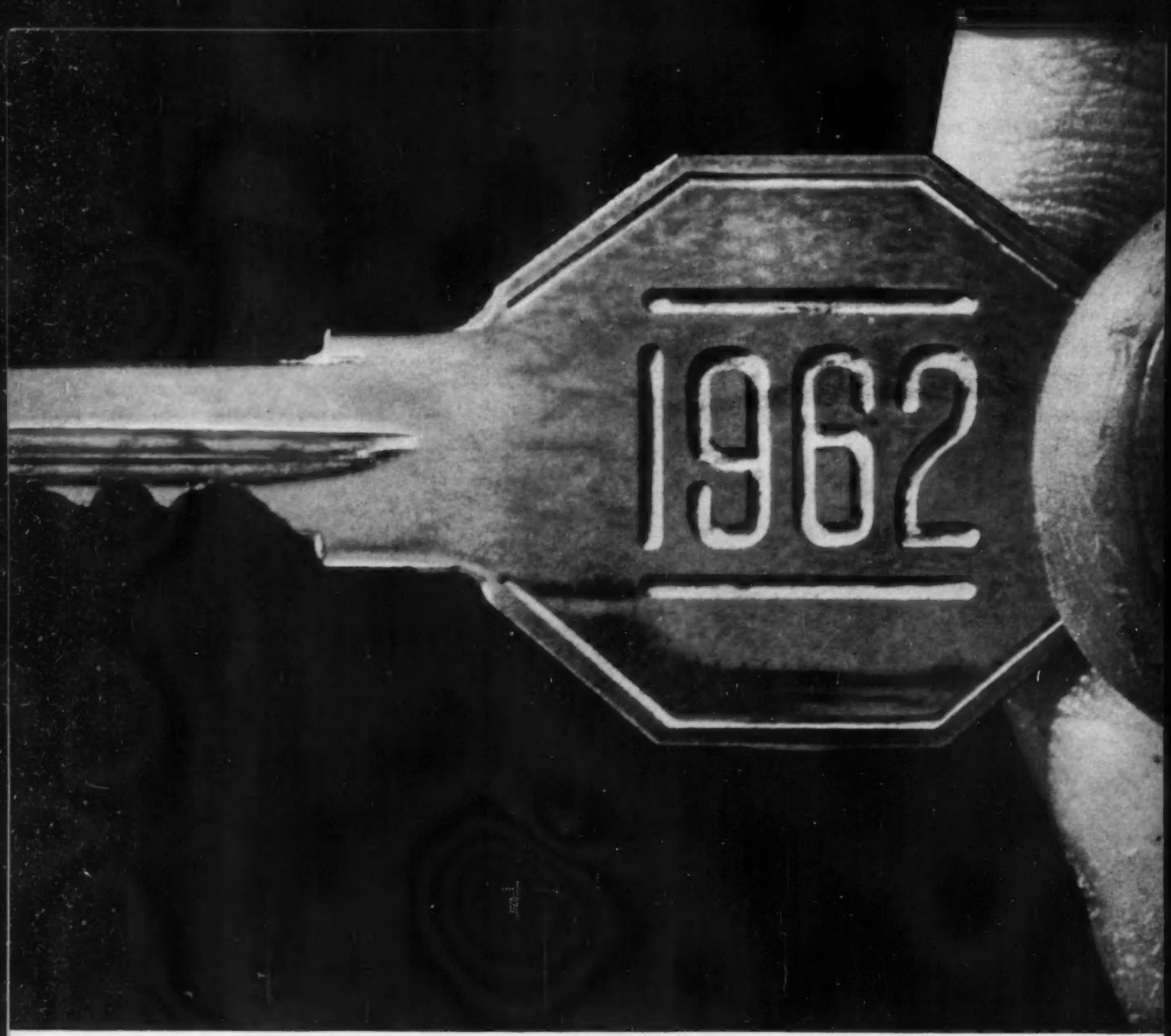


Bundyweld, double-walled from a single copper-plated steel strip, is metallurgically bonded through 360° of wall contact. It is lightweight and easily fabricated . . . has remarkably high bursting and fatigue strengths. Sizes available up to ⅝″ O.D.



Precision? Check this oil transfer tube mass-fabricated at Bundy. Two flanges are formed, as shown, with the opposite end of the tube held to .314″ with a tolerance of only .001″. Bundyweld has the superior ductility and strength needed for this type of tubing application.

BUNDYWELD® TUBING



A new feel in driving

When the nation's motorists turn the key...

. . . they'll agree. The new '62's act better. Look better. *Feel* better to drive than cars of any other year. In fact they're stepping out with more power per pound than any in history!

If the new cars feel better, it's largely because firms who supply parts to Detroit—working with Kaiser Aluminum—helped make each car *lighter* with aluminum.

Aluminum engines dump the weight. Ten per cent of the 1961 cars have aluminum engines. You will see more of them in future cars. One reason: the first big die-cast aluminum engine blocks—result of a ten-year die-casting development program by a casting supplier, assisted by Kaiser Aluminum.

These aluminum engine blocks can dump out as much as 200 pounds overall weight and bring other advantages of durability, cool running, and high production rate. Adding to a growing list of other aluminum parts—from transmission housings and brakes to hundreds of small items—aluminum engines are creating lighthearted new cars.

Trim new metals. One of the major contributions for '62 is victory in the search for dent-resistant aluminum for trim. The suppliers of trim guided development and factory tests of a new alloy—Kaiser Aluminum Alloy 5252. In the new cars Alloy 5252 delivers impact resistance and appearance comparable to more costly metals. Uses the same fasteners. Eliminates rust along trim edges. And knocks off still more dead weight.

starts here!

In each part where aluminum makes a debut in '62, it brings lightness, economy, performance . . . helps create a new feel in driving.

Kaiser Aluminum is pleased to be at the heart of this trend. Our plant on the Ohio River, at Ravenswood, W. Va., serves Detroit as the nearest fully integrated aluminum development and production center.

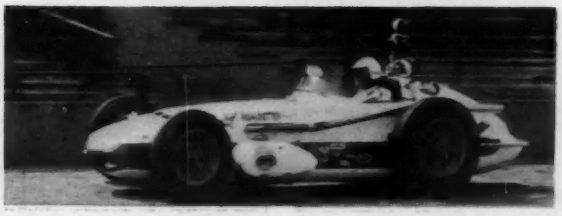
For experienced assistance in any automotive engineering or design problem that involves use of aluminum, contact Kaiser Aluminum Automotive Industry Division, IBM Bldg., Detroit 2, Michigan. Phone TRinity 3-8000. □

KAISER ALUMINUM

Watch Kaiser Aluminum's salute to lighthearted "Low Calorie Cars"

See Indianapolis winner Rodger Ward take the driver's seat for a thundering television message up to 170 mph. He'll be showing millions the advantages of lighter weight in beautiful "low calorie cars"—the slim, trim new 1962's!

On "Follow the Sun", Sundays, ABC-TV (Channel 7 in Detroit)



A new feel in driving starts here

These suppliers helped make the new '62 cars trim, light and powerful with Kaiser Aluminum:

Aluminum Specialty Company
Anderson Bolling Mfg. Co.
Bright-O, Inc.
Carter Carburetor Div. of Ace Industries, Inc.
Central Metal Products,
Division of Zenite Metal Products
C. Cowles & Company
C. M. Hall Lamp Company
Croname, Inc.
Detroit Engineering & Machine Co.
Detroit Gasket & Mfg. Co.
Doehler-Jarvis Division of National Lead Co.
Douglas & Lomason Co.
Eaton Manufacturing Company—
Stamping Division
The Electric Auto-Lite Company
Electro-Chemical Engraving Co., Inc.
Firestone Steel Products Co.
The Fox Company
General Motors Corporation Divisions:
A. C. Spark Plug; Brown-Lipe-Chapin; Central Foundry; Chevrolet Flint Mfg.; Delco Appliance; Delco Radio; Delco-Remy; Guide Lamp; Harrison Radiator; Rochester Products; Ternstedt
The Harrington & King Perforating Co., Inc.
Hayes Industries, Inc.
Hamill Mfg. Co., Inc.
Jervis Corporation
Kelsey-Hayes Co.
Keystone Metal Moulding Co.
Light Metals Corporation
Lescoa, Inc.
Lincoln Engineering Company
Div. of the McNeil Machine & Engineering Co.
Lobdell Emery Mfg. Co.
Metal Products Div. of Thompson Industries, Inc.
Mirro Aluminum Company
Namco Division of Hayes Industries, Inc.
National Decorated Metal Company, Inc.
Northern Engraving & Mfg. Co.
Peters Stamping Co.
Primeweld Corp.
Rogers Industries, Inc.
P. R. Mallory & Co., Inc.
Ryerson & Haynes, Inc.
Schlegel Mfg. Co., Inc.
Stamping Division—Chrysler Corporation
The Standard Products Co.
Tassell Hardware Co.
Wagner Electric Corporation

KAISER ALUMINUM

AUTOMOTIVE INDUSTRY DIV., IBM BLDG., DETROIT 2, MICH., TR. 3-8000

FUEL FILTER TEST METHODS TPS-1

An extensive report of new testing techniques in evaluating fuel filter capacity, pressure drop, and volume flow — and evaluation of media migration. Developed by the SAE Filter Test Methods Subcommittee, of the Engine Committee.

$2.50 to members
$5.00 to nonmembers

Please add 3% City Sales Tax
for orders delivered in New York City.

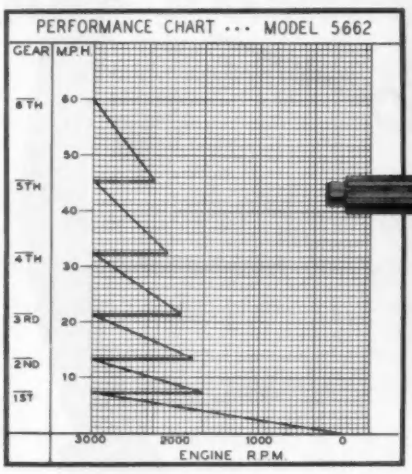
SAE JOURNAL

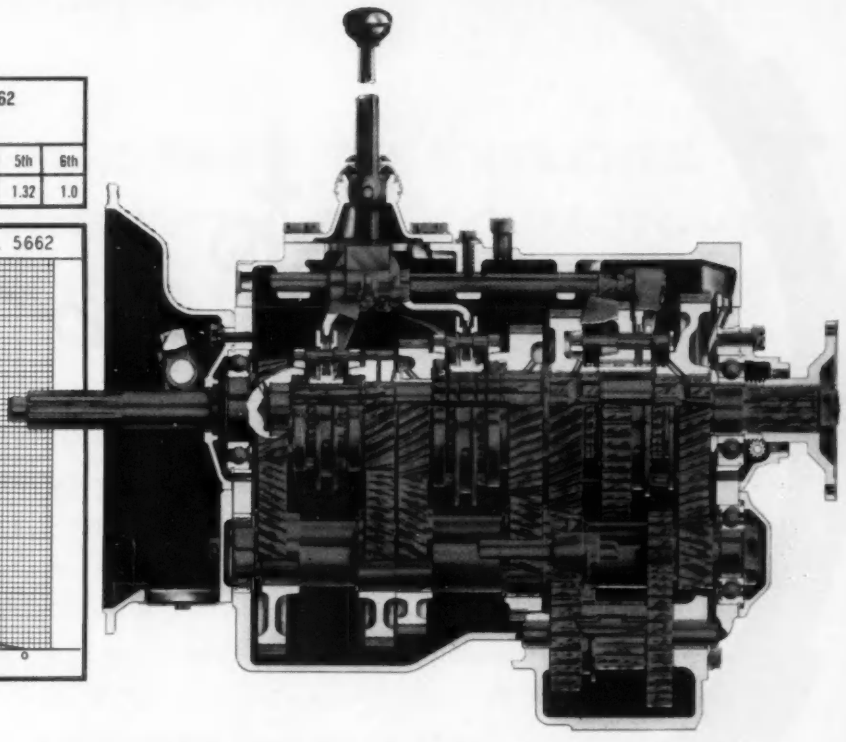
The AUTHORITY
on AUTOMOTIVE and
AIRCRAFT ENGINEERING

SAE JOURNAL
485 Lexington Ave.
New York 17, N.Y.

NEW SPICER 6-SPEED TRANSMISSION Offers Smoother, Faster Shifts For Over-The-Road Trucks!

GEAR RATIOS OF SPICER 5662 6-SPEED TRANSMISSION							
GEAR	Reverse	1st	2nd	3rd	4th	5th	6th
RATIOS	8.25	8.23	4.56	2.80	1.85	1.32	1.0





Direct Drive in 6th for High-Speed Engines

The New Model 5662 Spicer 6-speed transmission has direct drive in sixth, an 8.23 to 1 low gear ratio, a conventional shift pattern, and closer shift steps in top gears for more efficient highway performance. The top five speeds are fully synchronized for faster, smoother, no-clash shifting. Nominally rated at 375-400 lbs. ft. torque, the new unit is an ideal transmission for vehicles in the 60,000 GCW range.

Operators of trucks with 5-speed transmissions, particularly those with supplemental gearing who don't use all available ratios, will find the new Spicer 6-speed can eliminate the additional weight associated with such gearing.

The model 5662 6-speed teams up well with Spicer's newest 12″ two-plate, spring loaded clutch, and operates smoothly with Spicer's old reliables, the 14″ and 15½″ multiple lever, single-plate clutches. Cast iron case has standard SAE 6-bolt apertures for side-mounted PTO's. Case also adaptable for conventional overhead or remote control shifting.

For full information on the new Spicer Model 5662 transmission, write to Dana Corporation, Toledo 1, Ohio.

DANA Spicer

DANA CORPORATION

Toledo 1, Ohio

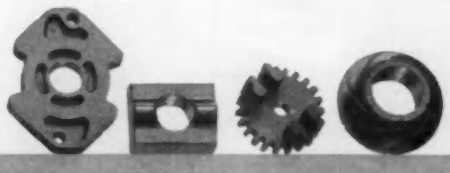
SERVING TRANSPORTATION—Transmissions • Auxiliaries Universal Joints • Clutches • Propeller Shafts • Power Take-Offs Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

NEW MODEL? NEW PRODUCT?

NOW'S THE TIME TO EXPLORE NEW SAVINGS WITH DELCO MORAINE SINTERED METAL PARTS

Designing or redesigning a product? Look carefully at components. If they're needed in quantity, Delco Moraine sintered metal parts may offer important advantages in cost, operating efficiency and improved reliability. It may be possible to design a single sintered part to replace a sub-assembly of several parts. Or eliminate the need for expensive machining operations. Or provide a special characteristic to lengthen product life, or improve performance. The controllable porosity of sintered metal parts, for example, permits impregnation with oil for lifetime self-lubrication. Give your new model or product every production break you can. Show components to engineers from Delco Moraine, a leader in the industry for forty years. They know when and how sintered metal parts can best be used. It's to your profit to know, too—and the best time to find out is now, in the planning stage.



DELCO MORAINE

Division of General Motors, Dayton, Ohio

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Steel *for Strength . . . Economy . . . Versatility*

Tests for Determining Mechanical Properties of Alloy Steels

The types of tests used to evaluate the mechanical properties of an alloy steel depend upon the end use of the steel involved. Mechanical properties are determined usually by tension, bend, and hardness tests, and by a group of special tests employed on tubular and wire products.

(1) *Tension tests* provide means of determining tensile strength, yield point, yield strength, proof stress, proportional limit, per cent elongation, and per cent reduction of area. This sort of test subjects the steel to stresses resulting from the application of an axial tensile load to the specimen ends, the load being sufficient to rupture the specimen.

(2) *Bend tests* often aid in determining the ductility of steel. The severity of such a test depends largely upon the bending radius used. Several factors influence the length of radius, including thickness of the test specimen, width of test specimen, direction of test, chemical composition, tensile strength of specimen, etc.

(3) *Hardness tests* determine the steel's resistance to penetration. This characteristic is most commonly measured by the Brinell Test or the Rockwell Test. In the former, pressure is applied to the surface of a test specimen by means of a ball 10 mm in diameter. Two diameters of the resulting impression are measured and averaged; the average is converted to the hardness number by means of a conversion table. In the Rockwell Test, the degree of hardness is read on a gage; hardness is measured by the penetration of a diamond point or a 1/16-in. steel ball. Rockwell "C" scale readings are used in connection with the diamond point; "B" scale in connection with the steel ball. The "C" and "B" are the most commonly used of the several Rockwell scales.

(4) *Special additional tests* are often made on tubular and wire products. These include such items as hydrostatic and manipulating tests, and torsion and wrapping tests, the latter two being used only with wire.

The subject of testing and its relationships to the end uses of alloy steels has been given broad study by Bethlehem metallurgists. If you desire, they will be glad to discuss any phase of it with you, and also give unbiased opinions on such matters as analysis, proper selection of steels, machinability, etc. Call for their services at any time.

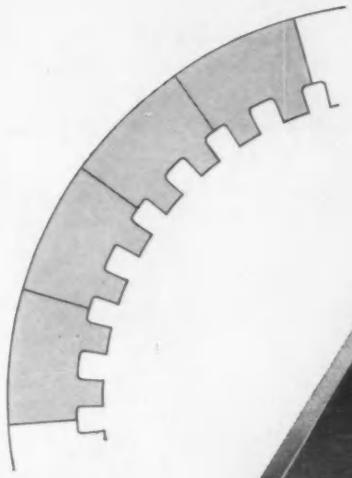
And when you need alloy steels, remember that Bethlehem furnishes the entire range of AISI standard analyses, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



practically unbroken bearing surface of the new, one-piece uniseal

OIL CONTROL RING

UNISEAL OIL RING

The new Uniseal Oil Ring gives you the advantages of a multi-segment ring in a one-piece oil control ring. Here are some of the important features:

1—Long life is assured through the elimination of pieces which wear against each other.

2—Single piece ring offers basic installation and inventory economies.

3—Circumferential expansion action coupled with multi-segment construction gives optimum conformability.

4—High conformability allows low total loading resulting in lower friction.

5—Deep channel construction makes it exceptionally free from carbon clogging.

In the new Uniseal Ring, spaces between the segments close to prevent oil passage. End clearance is maintained by the Uni-Gaps — super spacers, one on either side. Sides are precision ground to provide maximum side sealing of oil groove. Quick seating is accomplished by narrowing the cylinder contact faces. Let us show you other important features of this and other new Ramco Engineered Designs. A phone call or letter will do it.

***Piston Rings by* THOMPSON PRODUCTS RAMCO DIVISION**

Thompson Ramo Wooldridge Inc. • P. O. Box 513
Dept. Q St. Louis 66, Mo.

TRW

AUTOMOTIVE GROUP

THOMPSON PRODUCTS LIGHT METALS DIVISION | THOMPSON PRODUCTS MICHIGAN DIVISION | THOMPSON PRODUCTS VALVE DIVISION | THOMPSON PRODUCTS RAMCO DIVISION | THOMPSON PRODUCTS MOTOR EQUIPMENT MANUFACTURING DIVISION

Copyright 1961 Ramsey Corporation O-109

Some Ideas

for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

Six years ago, K&E introduced the very first polyester-base drafting film—a special-purpose medium featuring extreme dimensional stability. Experience with that film indicated that a definite need also existed for a *general-purpose* drafting film, if one could be perfected. About two and a half years ago we succeeded, introducing HERCULENE® Drafting Film – the first polyester-base medium for general drafting to meet professional standards. Many recognized its value immediately, stocked up on HERCULENE, and have used it happily ever since. Others – a bit more "canny" about adopting a relatively untried medium – deferred decision, saying "see us in a year or so." Still others – having tried one or more of the other films marketed immediately after HERCULENE – seemed permanently disenchanted with *all* film based media. What with the passage of time and much favorable ado about drafting films in general, we rather think that those once stung may now have adopted a more congenial attitude – so we address ourselves solely:

To fence-sitters everywhere . . .

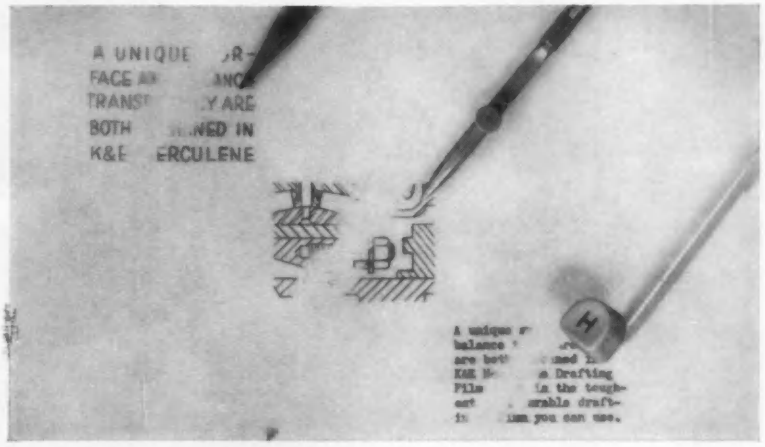
Just as we felt in '58, we feel today, that film has an important place in the drafting room. The only difference now is that experience has *proved* it so. Since 1958, the number of HERCULENE users has grown by leaps and bounds. All, we're happy to say, have found HERCULENE a welcome, efficient, and *much needed* addition to their stock of drafting media. It is these HERCULENE users who have written the record. Their many and rigorous tests, their months of experience, their numerous successes and continuing satisfaction are convincing evidence that HERCULENE is all we said it would be.

Why all the fuss about HERCULENE? . . .

HERCULENE combines practically all the qualities of a perfect drafting medium. An excellent product when introduced, it's even closer to perfection today. Working with major film users, K&E specialists have refined HERCULENE in many subtle ways since its introduction.

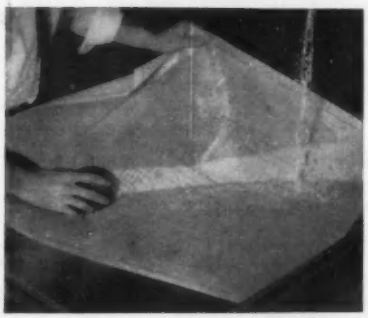
Unlike cloth or paper, HERCULENE is virtually indestructible. No matter how roughly or frequently a HERCULENE tracing is handled, it will never crack, wrinkle or fade. Absolutely waterproof, a HERCULENE drawing can never be permeated and ruined by moisture. Filed away, HERCULENE will last indefinitely. And HERCULENE has body, too, making it far easier to handle and file, and to keep flat on the drawing board.

Most of the refinements made in HERCULENE since 1958 have concerned its engineered drafting surface. HERCULENE's surface "take" for pencil, ink and typing is now better than ever. Erasability, of course, is excellent for all three. Contrast has been built up for sharper definition of line, too, yet all the transparency necessary for fast, clear reproductions has been maintained.



Two big bonuses, too . . .

A significant chapter in the HERCULENE story has been the development of a waterproof writing mate – the Duralar plastic pencil. Drawings made on HERCULENE with this waterproof pencil can actually be



washed in soap and water. Even gray, grimy "unreproducible" drawings can be washed spotless with this new technique. Many firms now use the HERCULENE/Duralar team exclusively . . . and are realizing undreamt-of savings in costly re-draws.

Some firms, of course, by virtue of smaller work volumes and "cleaner" or less frequent handling, will have little need for this new wash technique. Of particular interest here is another K&E exclusive recently introduced – the amazing Ruwe pencil. The Ruwe pencil will not withstand washing, but in every other respect, this new pencil is graphite-*plus*. Although of plastic composition, the Ruwe pencil has all the "fine" feel of graphite, erases well, and deposits a sharp, dense black line. The big bonus: Ruwe pencil lines are *virtually smudge-proof*. Rendered on HERCULENE's engineered drafting surface, they actually resist smudging better than graphite on regular paper!

We leave it to you . . .

The best test remains the one you make for yourself. We've just completed a new brochure, titled "A Report on the Growing Acceptance of Polyester Film." In it is detailed most of what we have learned about HERCULENE and its use since 1958 – including tests you can make to assess its every property. We'd like you to have a copy of this new brochure – plus a sample sheet of HERCULENE, a Duralar pencil, and a Ruwe pencil – for your own private testing. To get these free samples, simply fill out and mail the coupon below:

KEUFFEL & ESSER CO., Dept. SJ-11, Hoboken, N. J.

Gentlemen:

Please send me your new brochure, titled "A Report on the Growing Acceptance of Polyester Film," a sample sheet of HERCULENE Drafting Film, and samples of the Ruwe and Duralar Pencils.

Name & Title _____

Company & Address _____

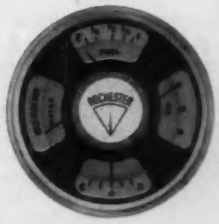
4031

Designed for "Round-the-Clock" tractor operations

NOW—with Rochester's new line of "electroluminescence" panel gauges—you can help tractor operators eliminate costly downtime because of engine failure through inability to read gauges during "afterdark" operations.

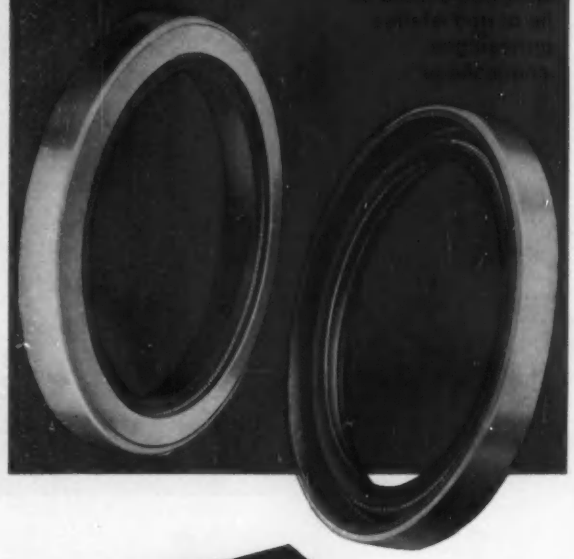
Because they give off a constant glow of light, these new Rochester gauges keep night-shift tractor, 'cat and bulldozer drivers aware at all times of vitally important oil pressures, charge rates, water temperatures and gas tank levels. This all-new plate form of direct dial lighting is fully permanent. It does not require replacement and is completely sealed against dust, oil, moisture and weather. There are no bulbs to break, burn out or go dim.

If you are designing for the tractor and implement market get the Rochester story —NOW. This new panel light utilizes the phenomenon of electroluminescence to produce a thin area type of light. This is in direct contrast to incandescent lights which are basically a point source. They are available in both cluster and individual gauge types. For complete information write to American-Standard Controls Division, 5900 Trumbull, Detroit 8, Michigan.



AMERICAN-Standard
CONTROLS DIVISION

WESTON
OIL SEALS



Enquiries to:

CHARLES WESTON of CANADA LTD

Head Office: 1001 Beaumont Avenue, Montreal, Q. Quebec.
Branch: 1283 Caledonia Road, Toronto, Ontario.

Distributors for British & European Car Seals:-

UNITED STATES: Johnson Bronze Co., Newcastle, Penn., U.S.A.

CANADA: Lansair Limited, 1001 Beaumont Avenue, Montreal, P. Quebec.

Branches: Toronto, Winnipeg, Edmonton, Vancouver.

Want One For Your Lapel?

An SAE Emblem

- Distinguishes you as an SAE member
- Is an attractive gold-filled clutch-back pin
- Costs only $1.50
  plus
  15¢ Federal tax for delivery in the United States and 5¢ sales tax for delivery in New York City

ACTUAL SIZE

GOLD on BLUE ..... Member Grade
GOLD on RED ..... Associate Grade
GOLD on WHITE ..... Junior Grade

Society of Automotive Engineers
485 Lexington Ave., New York 17, N. Y.

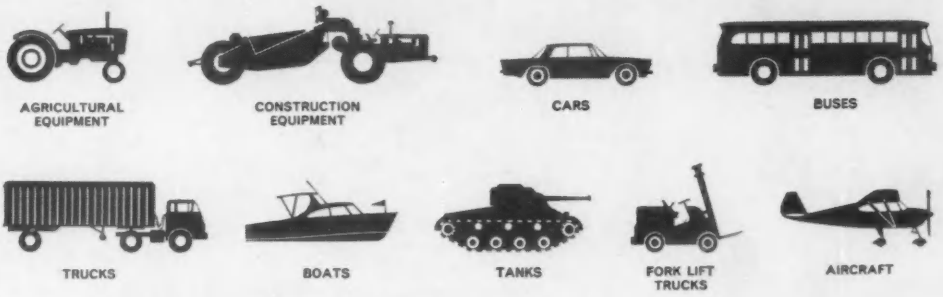
Please send me an SAE emblem. Enclosed is my check for $..... ($1.50 plus applicable taxes). Grade of membership (please check)

☐ Member ☐ Associate ☐ Junior

Name .....
(PLEASE PRINT)

Address .....

ACROSS-THE-BOARD DEPENDABILITY



WITH BENDIX ELECTRIC FUEL PUMPS

On practically every type engine, the Bendix® Electric Fuel Pump outperforms all others in or near its price class. It eliminates vapor lock, assures faster starts in cold weather, immediate re-starts in hot weather. It offers built-in pressure release, delivers more gallons per hour. The pump is simple to install and service; has proved dependable in temperatures ranging from +150° to −76° F. For built-in reliability, specify Bendix Electric Fuel Pumps. Eclipse Machine Division, Elmira, N. Y.

Export Sales and Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Bendix-Elmira THE Bendix CORPORATION

---

users! manufacturers!

MOBILE RADIO TELEPHONE FOR AUTOMOTIVE USE

TR-27

This report is a revision to the obsolete Two-Way Radio Communications Suitable for Automotive Fleet Operation. The primary scope of this report is to supply essential information to the ultimate user of vehicles and mobile radio equipment and also supply the equipment manufacturers with useful data. This report contains: General Information, Physical Dimensions, Equipment and Space Requirements, Vehicle Power Supply System, Installation and Maintenance, User's Manual at Base Station, User's Manual at Mobile Station, and Selective Calling.

Price: $1.50 to members
$3.00 to non-members

Society of Automotive Engineers, Inc. • **485 Lexington Ave.** • **New York 17, N. Y.**

Coupons Save Time & Money

FIFTEEN DOLLARS
WORTH OF COUPONS

FOR PURCHASING SAE
MEETINGS PAPERS
AND GENERAL
PUBLICATIONS

PRICE: $13.40

Each of the twenty coupons inside will be accepted as the equivalent of 75c when purchasing SAE meetings papers and General Publications.

Not acceptable for periodicals or for dues.
Not redeemable or transferable.

VALID TO SEPT. 30, 1964

No. 1

Society of Automotive Engineers
485 Lexington Avenue
New York 17, N. Y.

- each coupon book buys $15.00 worth of SAE meetings papers and General Publications; it costs $13.40. Each coupon is worth 75¢.
- each book is good for a minimum of two years.
- coupons will be accepted at National Meetings or with mail orders for SAE meetings papers and General Publications.
- coupon books save you time and trouble.

ORDER BLANK

(It is requested that cash or check accompany your order for coupon books)
Add 3% city sales tax for deliveries in N. Y. C.

GENERAL PUBLICATIONS DEPT.
Society of Automotive Engineers
485 Lexington Avenue
New York 17, N. Y.

Please send me .... SAE coupon books at $13.40 each. (Check) (Cash) for .... is enclosed.

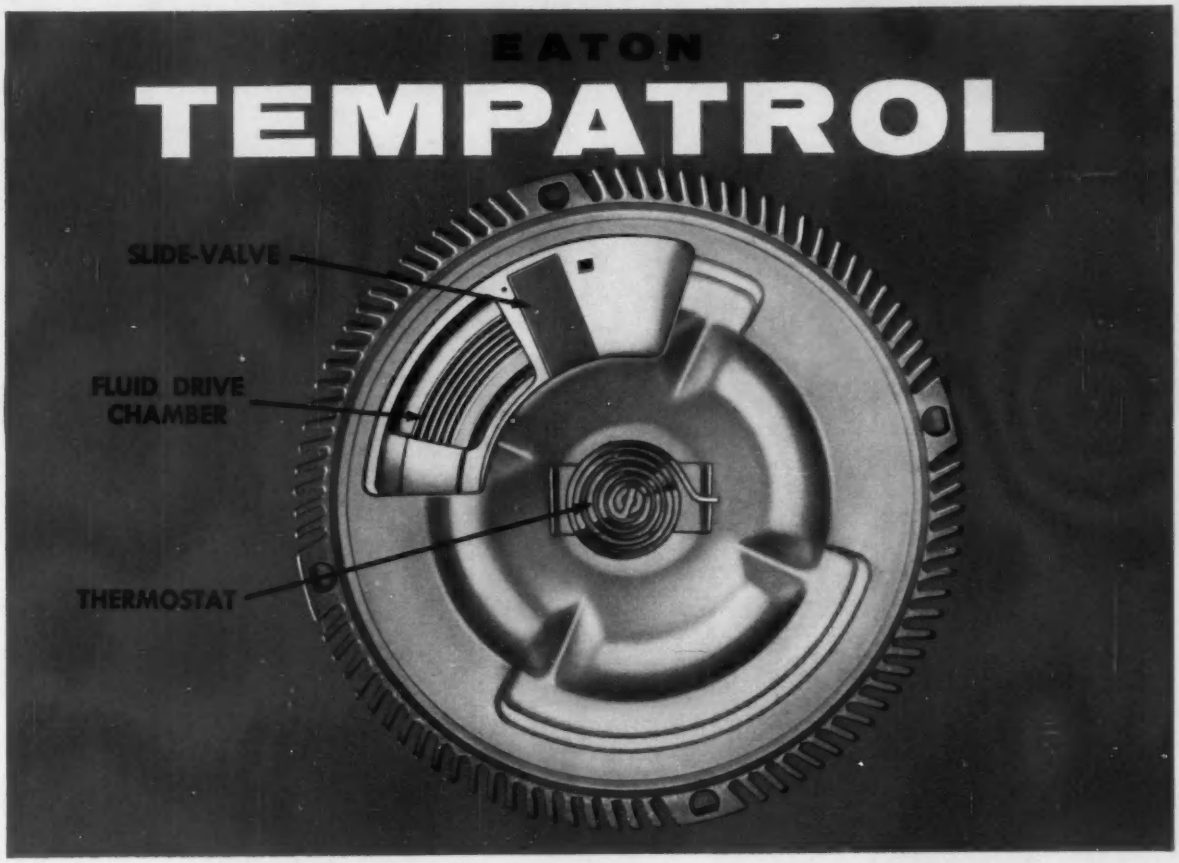
Name _____

Company Name _____

Company Address _____

EATON

TEMPATROL



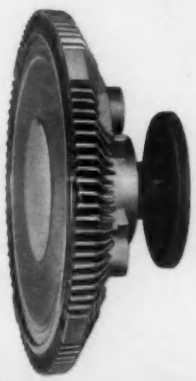
Temperature Regulated Fan Drive Increases Usable HP— Reduces Fan Noise

HOW TEMPATROL WORKS: When under-hood temperature is below the thermostat setting, slide-valve is closed; fluid-drive chamber is empty; the fan idles.

With a rise in under-hood temperature above the thermostat setting, slide-valve opens; fluid enters viscous drive chamber, increasing fan rpm to a pre-determined limit for adequate cooling.

- When cooling is not required, the thermostatic unit causes the fan to idle, thereby increasing net engine output.
- With the Tempatrol Drive engaged, adequate cooling can be achieved at low engine speeds. The top fan speed is controlled to a pre-determined maximum to avoid excessive noise.
- Operational ranges can be established to suit the requirements of each vehicle.

Eaton Tempatrol Fan Drives are readily adaptable to existing installations with only minor changes. They are now operating efficiently on leading motor vehicles. Consult with our engineers on your fan drive needs.



TORQATROL is the torque-regulated version of the Eaton Viscous Fan Drive (without thermostatic control). At low engine rpm, the fan operates at driven speeds. As engine speed increases, the viscous drive slips, limiting the maximum fan speed. Maximum fan speed limit can be raised or lowered to suit the needs of specific installations.

Tempatrol and Torqatrol are fan drive units in the family of Eaton Visco-Drives.®

EATON

MARSHALL DIVISION

MANUFACTURING COMPANY

9771 FRENCH ROAD • DETROIT 13, MICHIGAN

Inter-State
MOTOR FREIGHT SYSTEM

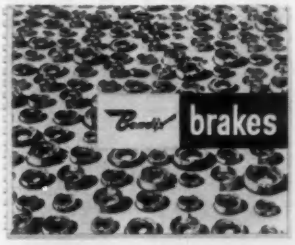
BRAKE HEADQUARTERS OF THE WORLD

WHATEVER THE VEHICLE BENDIX HAS A BRAKE TO STOP IT BETTER!

Regardless of size, shape, or power of the vehicle, Bendix makes a brake to stop it more safely, surely. Currently, we're producing over 400 different types of automotive brakes alone, so the answer to a specific brake problem probably is included in our line. If not, we will design and produce the brake that meets the exact need.

Bendix® brakes are quality-built—made to our high standards of reliability and long service. Forty years' experience and over 141,000,000 brakes sold are your assurance that you get quality when you specify Bendix. Bendix conducts more research and testing than any other brake manufacturer, both in the laboratory and in the field.

Got a brake problem? Let us help you analyze and solve it. Call, wire or write our Automotive Brake Department, Customer Applications Engineering, at South Bend.



FREE 82-PAGE BRAKE CATALOG

Shows brakes for almost every application. Gives complete axle load rating data. Details brake torque capacity ratings. Provides installation data. Discusses Duo-Servo® and non-servo hydraulic and mechanical brakes; Twinplex® and uni-servo hydraulic brakes; auxiliary mechanical brakes; new band/disc brake. Write for your free copy.

BENDIX BUILDS MORE BRAKES FOR MORE DIFFERENT VEHICLES THAN ANY OTHER MANUFACTURER

Bendix Automotive Products Division

THE Bendix CORPORATION

WHAT'S NEWS IN ENJAY RESINS FOR SURFACE COATINGS

Alkyd Melamine
After 500 Hours
Salt Spray

Epoxy Ester
After 700 Hours
Salt Spray

Buton 200
After 700 Hours
Salt Spray

BUTON® 200 Resin offers better corrosion resistance—saves up to 1/3 the cost

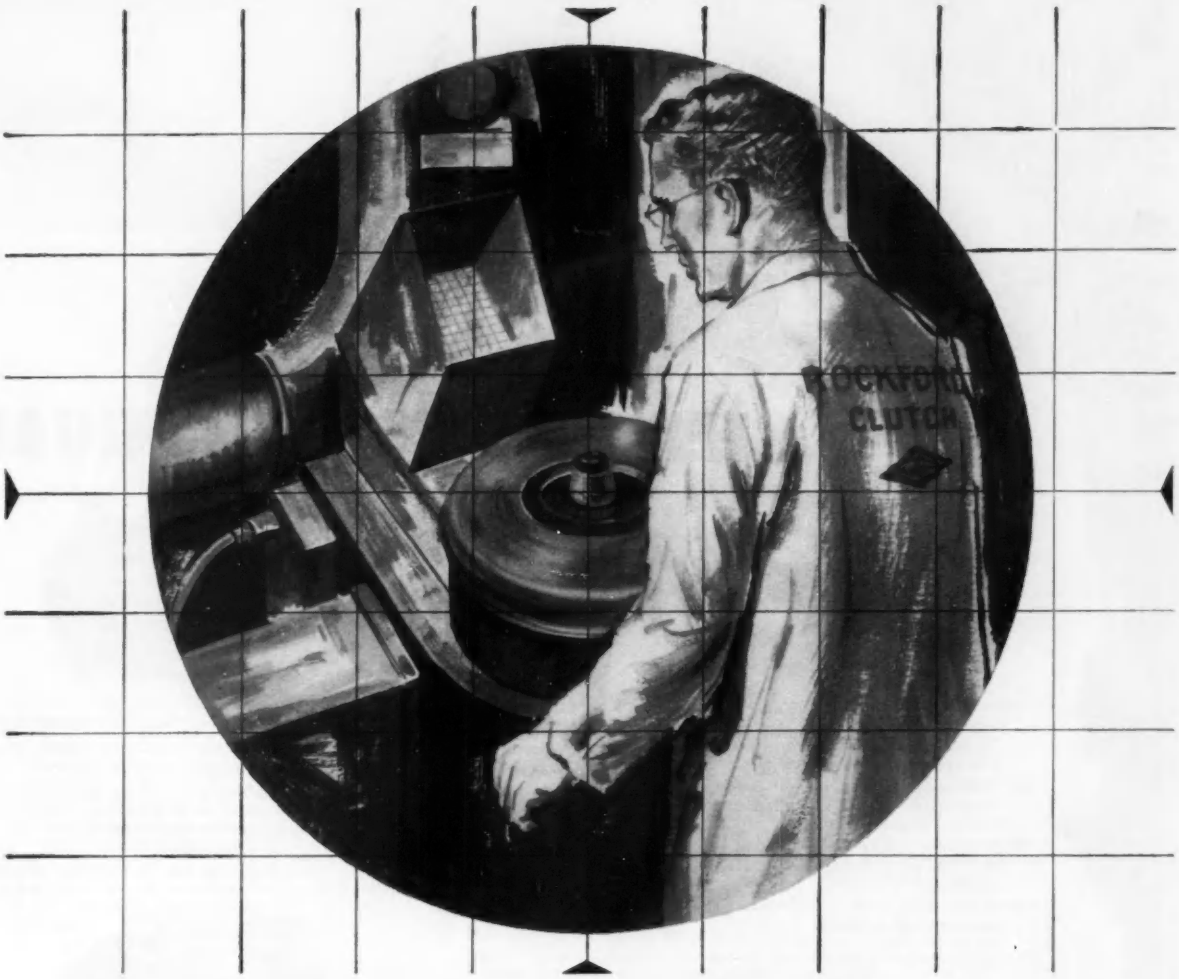
In a recent series of salt spray tests, Buton 200 Resin outperformed epoxy ester and alkyd melamine formulations. All samples were automotive primer formulations with equivalent pigmentation. Test results? The Buton based primer had the lowest creep of all three. Impact testing also revealed that Buton-based primers had good adhesion, flexibility and impact resistance. By selecting Buton 200 Resin, you can save up to ⅓ on metal primers. Samples and a booklet on Buton Resins for metal primers may be obtained by writing to 15 West 51st Street, New York 19, N. Y.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY
RESINS



DYNAMIC BALANCING ELIMINATES CLUTCH VIBRATION

assures you smooth, enduring clutch performance

Rockford Clutches are vibration free . . . This means your on and off-highway vehicles or industrial machinery get extra-long clutch life, top power from your engines and extremely smooth engagements. Rockford eliminates vibration by dynamically and statically balancing each clutch. Above, a Rockford man spins a clutch on a special balancing machine. He then views electronic scope for vibrational-blips and removes heavy spots to insure perfect balance. Clutch vibration can ruin bearings . . . crack housings . . . damage crankshafts or other essential components. Consider the operator of your equipment . . . freedom from vibration means quite a bit to him, too. No uncomfortable nerve-jangling work here. Yes, quality construction is Rockford's key to efficient clutch reliability. Rockford offers a wide range of power controls. Write today for illustrated brochure.

ROCKFORD CLUTCH

1233 WINDSOR ROAD ◆ ROCKFORD, ILLINOIS

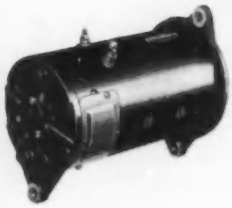
Export Sales Borg-Warner International, 36 South Wabash, Chicago, Ill.

ROCKFORD CLUTCH DIVISION BORG-WARNER

ROCKFORD BW CLUTCH

DIVISION OF BORG-WARNER

KEEP YOUR OFF-THE-ROAD

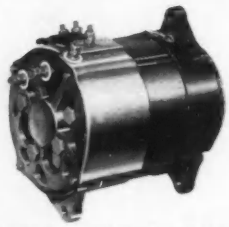


HEAVY-DUTY, LONG-LIFE D.C. GENERATOR

- Double-length, double-life brushes with constant-tension springs
- Ball bearings with sealed grease reservoirs—need no lubrication between engine overhauls
- 50-ampere maximum output—available with 10-ampere output at engine idle
- Sealed field coils—impervious to moisture and corrosion

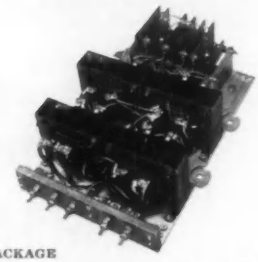
SELF-RECTIFYING A.C. GENERATOR

- Built-in silicon diodes eliminate external rectifier
- 30-ampere output at normal engine idle
- 60- or 85-ampere maximum output models available
- Ball bearings with sealed grease reservoirs—need no lubrication between engine overhauls



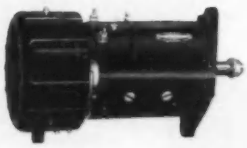
EXTRA-HIGH-OUTPUT A.C. GENERATOR

- 130-ampere maximum output
- 40 amperes at engine idle
- Three-phase a.c. voltage available—ideal for 120-volt conversion as a power source for mobile d.c. power equipment
- Ball bearings with sealed grease reservoirs—need no lubrication between engine overhauls



FAN AND SHROUD ENCLOSED D.C. GENERATORS

- Totally enclosed for protection against foreign materials
- 12-volt—24- and 40-ampere maximum outputs. 24-volt—15- and 20-ampere maximum output generators available
- Double-life brushes and constant-tension brush springs
- Ball bearings with sealed grease reservoirs—need no lubrication between engine overhauls



POWER SUPPLY PACKAGE

- Rectifies and transforms vehicle generator voltage up to 120 volts d.c.
- Furnishes dependable power up to 1200 watts
- Provides mobile power suitable for incandescent lights, universal motors, d.c. motors, a.c.-d.c. radios, resistive loads without thermostats, or other 120-volt d.c. equipment

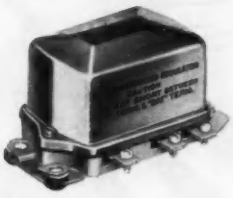
SPECIFY DELCO-REMY POWER-MATCHED ELECTRICAL SYSTEMS!

It's the sure way to prevent downtime and costly repairs caused by inadequate electrical systems. With Delco-Remy's broad line of complete systems and individual components, you can match electrical power exactly to the special needs of your equipment. New design concepts and construction features mean Delco-Remy units last longer, require little or no periodic servicing and deliver more dependable operation under *all* conditions. The particular Delco-Remy system that'll prove

EQUIPMENT ON THE JOB . . .

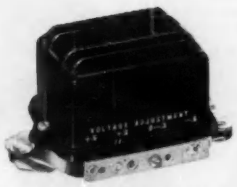
DOUBLE CONTACT GENERATOR REGULATOR

- Double contacts provide better voltage control—longer service life
- Simplified external adjustment feature quickly tailors voltage to job
- Waterproofing insures long life and reliable operation



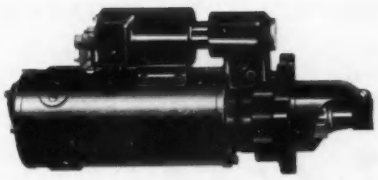
TRANSISTORIZED REGULATOR

- Vibrating type voltage sensor plus single transistor extends service life
- Accurate voltage control at all generator speeds
- Available with simplified external voltage adjustment feature
- Available for either indicator light or ammeter circuits



FULL-TRANSISTOR REGULATOR

- No moving parts to wear out
- Requires no periodic servicing
- Constant voltage control—unaffected by temperature changes, vibration or mounting position
- Simplified external adjustment feature—permits tailoring voltage to operating conditions



HIGH-DUTY CRANKING MOTOR

- New high-performance 12-v. motor eliminates need for series parallel switch circuits with no increase in battery capacity—24- and 32-volt models also available
- Two-piece housing permits 24 different solenoid positions, reduces number of models and spare parts needed
- Totally enclosed drive shifting mechanism is protected against dirt, water, slush and ice
- Heavy-duty sprag clutch remains engaged until engine starts—improves cold weather starting

DC-250 HIGH-DUTY BATTERIES

- Glass mat retainers protect positive plate material—improve cycling ability, provide longer service life
- Resin seals between cell cover and terminal and between case and cell cover protect plates and separators from vibration damage and prevent electrolyte loss
- Newly formulated positive plate material withstands vibration and cycling damage—delivers dependable power during longer life span of DC-250

most economical for your needs depends on your equipment's job and its performance requirements. Ask your dealer about Delco-Remy power-matched electrical systems and specify them when ordering new vehicles. And, to bring your present equipment up to date, contact your United Delco Distributor.

Delco Remy

DELCO-REMY • DIVISION OF GENERAL MOTORS • ANDERSON, INDIANA

SAE AUTOMOTIVE DRAFTING MANUAL

TR-66

NEW! 3rd Edition

Society of Automotive Engineers, Inc., 485 Lexington Avenue, New York 17. N. Y.

Please send me the new, third edition of the SAE Automotive Drafting Manual.
It is priced at $8.00 to members and $16.00 to non-members.
NOTE: Please add 3% city sales tax for deliveries in New York City.

___CHECK OR COUPONS ENC.
___BILL COMPANY
___BILL ME

NAME_____
COMPANY_____
COMPANY ADDRESS_____

___FREE CHECKLIST OF SPECIAL PUBLICATIONS AND MEETINGS PAPERS

___FREE CHECKLIST OF CRC REPORTS

PROTECTS THE PERFORMANCE YOU PROMISE!

Hobbs HOUR METERS

ASSURE "ON TIME" MAINTENANCE

A recommended program of planned maintenance based on OPERATING TIME promotes better care of your product through correct attention at the right time — helps protect its reputation for top performance and dependability.

HOBBS HOUR METER is a true electric timing instrument which shows operating time in hours and minutes. No revolution counter can give a reliable indication of total engine time in all speed ranges. These efficient elapsed time indicators can also provide a realistic basis for buying and selling used equipment — show the actual running time of leased equipment. Ideal for warranties and service contracts. Models available for Alternating Current and Direct Current.

COMPLETE LINE OF PRESSURE SWITCHES

Industry approved for a wide range of applications — single circuit and dual circuit; grounded and non-grounded; preset pressure ranges of from 3 to 60 psi. Pretested at 150 psi.

Also manufacturers of shock-mounted head, tail and dash lights for off-the-highway equipment.

Distributors in Principal Cities
WRITE FOR CATALOG 600

Symbol of SW Excellence

John W. Hobbs Corporation
A DIVISION OF STEWART-WARNER CORPORATION
2059 YALE BLVD., SPRINGFIELD, ILLINOIS

SOUTHWEST
"Monoball"®
SELF-ALIGNING BEARINGS

PATENTED U. S. A.
All World Rights Reserved

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.
4	"Dyflon"® Plastic Alloy Inserts. CRES Ball and Race. Chrome Alloy Steels.	For types operating under rotational, high radial loads and long cycle life where lubrication is impossible.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Our engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. Write for Engineering Manual No. 551. Address Dept. SAE-61

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Fuel Filter Test Methods
TPS-1

An extensive report of new testing techniques in evaluating fuel filter capacity, pressure drop, and volume flow — and evaluation of media migration. Developed by the SAE Filter Test Methods Subcommittee, of the Engine Committee.

$2.50 to members
$5.00 to nonmembers

Please add 3% City Sales Tax for orders delivered in New York City

For any automotive use of

MOLDED FIBER GLASS

Call the pioneers and experts.
Free literature, counsel and quotations.
No obligation. Write:

Molded Fiber Glass Body Co.
4639 Benefit Avenue • Ashtabula, Ohio

Now Goodyear rims are precision-

These new Goodyear precision rims, for over-the-road use, are built to such close tolerances they better industry standards by *a full fifty per cent*.

What's more, Lateral and Radial Runout will not exceed 1/32 of an inch.

For *equipment manufacturers* this means a complete line of over-the-road rims to match the most accurately made wheels for use on their equipment.

For *fleet owners and operators* the immediate benefits are longer tire mileage, less down

Lots of good things come from GOOD

built to run 50% truer

time and a lower cost-per-mile operation. Vibration is markedly reduced and so is driver fatigue.

Whether you're a manufacturer or the owner of one truck or of an entire fleet of trucks, it will pay you to specify these revolutionary new rims. For additional information on what they can do to improve operating efficiency and lower your costs, write Goodyear, Metal Products Division, Akron 16, Ohio. Or, if you prefer, get in touch with your local Goodyear Rim Distributor.

YEAR

More tons are carried
on Goodyear rims
than on any other kind

+ INDEX TO ADVERTISERS +

A

AiResearch Mfg. Corp. 160
Allegheny Ludlum Steel Corp. 25
American Standard Controls Div. .. 177

B

Bearings Company of America ... 158
Bendix Corp.
Automotive Products Div. 28, 182, 183
Eclipse Machine — Fuel Pump . 179
Eclipse Machine — Starter Drive 159
Eclipse Machine — Stromberg Carburetor 144
Bestwall Gypsum Co. 151
Bethlehem Steel Co. 174
Borg & Beck Div. Borg-Warner Corp. 3
Borg-Warner Corp. ..... 3rd Cover
Bower Roller Bearing Div. Federal-Mogul-Bower Bearings, Inc. 147
Bundy Tubing Co. 166, 167

C

Cameron Iron Works, Inc. 4
Century Gas Equipment Marvel-Schebler Products Div. Borg-Warner Corp. 129
Chicago Rawhide Mfg. Co. 26
Chicago Screw Co. Div. Standard Screw Co. 139

D

Dana Corp. 171
Delco Moraine Div. General Motors Corp. 172, 173
Delco Radio Div. General Motors Corp. 140, 141
Delco Remy Div. General Motors Corp. 186, 187
Dow Chemical Co. 16
E. I. du Pont de Nemours & Co., (Inc.) Elastomers Div. 155

E

Eaton Mfg. Co. Marshall Div. 181
Enjay Chemical Co., Div. of Humble Oil & Refining Co. Butyn 184
Escon 149
Evans Products Co. 152

F

Federal-Mogul Div., Federal-Mogul-Bower Bearings, Inc. 15
Felt Products Mfg. Co. 143
Formrite Tube Co. 130
Formsprag Co. 137
Fuller Transmission Div. Subsidiary Eaton Mfg. Co. 136

G

Goetzewerke 20
Goodyear Tire & Rubber Co. Metal Products 190, 191
Great Lakes Steel Corp. 156, 157
Guide Lamp Div. General Motors Corp. 9

H

John W. Hobbs Corp. 189

I

International Nickel Co. 21
International Packings Corp. 14

J

Johnson Products, Inc. 133

K

Kaiser Aluminum & Chemical Corp. 168, 169, 170
Kelsey Hayes Co. 162
Keuffel & Esser Co. 176

L

Lipe Rollway Corp. 131

M

McLouth Steel Corp. 148
McQuay-Norris Mfg. Co. 19
Mechanics Universal Joint Div. Borg-Warner Corp. 10
Molded Fiber Glass Body Co. 189
Morse Chain Co., Div. Borg-Warner Corp. "A Borg-Warner Industry" .. 153

N

National Seal Div., Federal-Mogul-Bower Bearings, Inc. 11

O

Oronite Div., California Chemical Co. 22, 23

P

Perfect Circle Corp. ..... 2nd Cover
Precision Rubber Products Corp. . 145

R

Rockford Clutch Div. Borg-Warner Corp. 185
Rockwell Standard Corp. Transmission & Axle Div. .. 150, 164
Rollway Bearing Co. 24
Ross Gear & Tool Co., Inc. 132

S

Screw & Bolt Corp. of America .. 128
Schlegel Mfg. Co. 193
Sealed Power Corp. 135
Southwest Products Co. 189
Stackpole Carbon Co. 142
Sun Electric Corp. 18

T

Thompson Ramo Wooldridge, Inc. Ramco Piston Ring Div. 175
Timken Roller Bearing Co. . 4th Cover
The Torrington Co. 138
Tung-Sol Electric, Inc. 163

U

United-Carr Fastener Corp. 7
U. S. Rubber Co., (Naugatuck Chemicals) 17, 161

W

Wagner Electric Corp. 12, 13
Waukesha Motor Co. 154
Western Felt Works 8
Charles Weston & Co., Ltd. 178
S. S. White Dental Mfg. Co. 134
Wico Ignition Div. Globe-Union Inc. 146
Wyman Gordon Co. 125

XYZ

Youngstown Sheet & Tube Co. 126, 127
Zollner Corp. 194

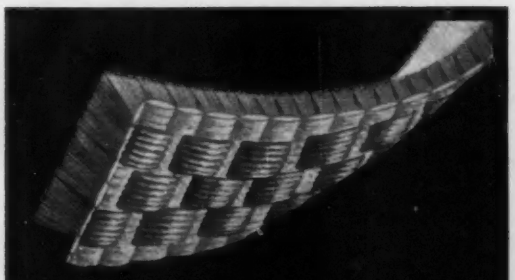
How to design a car window that won't rattle, leak or stick . . . FOR THE LIFE OF THE CAR!

Manufacture every part to work perfectly *for the life of the car.*

For instance, the pile channel liners. They'd have to be Schlegel. *Woven backing.* It's almost impossible to pull the pile out of Schlegel's interwoven backing. Every individual strand of yarn is interlocked with the woven fabric backing.

It's just as difficult to wear it out. Try it in your wear-testing machines. Schlegel blends exactly the right balance of natural and artificial fibers for maximum resilience and long life.

The result—quiet, friction-free, weathertight windows, for the life of the car. The methodology—specify Schlegel pile in your window channel or weatherstrip. You'll be in good company. Auto engineers have been specifying Schlegel pile since glass windows were first used in cars.



Each individual strand of yarn is locked through and around a strong fabric backing, resulting in permanent, inseparable binding of pile ends.

Schlegel

SERVING THE AUTOMOTIVE INDUSTRY

SCHLEGEL MANUFACTURING COMPANY

1555 Jefferson Rd., Rochester 23, N. Y. • In Canada: Oakville, Ontario

TOP PISTON POWER FOR DIESEL ENGINES

BOND LOC

STOPS GROOVE WEAR

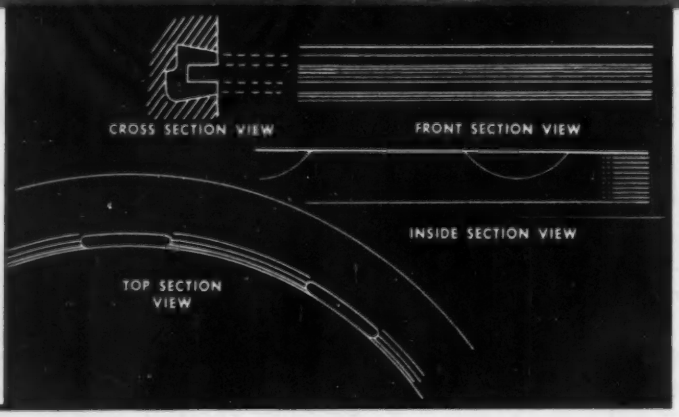
"NI-RESIST" IRON
TOP RING SECTION

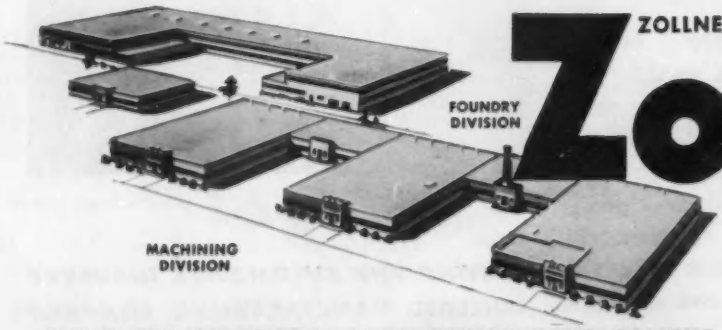
Double Bonded

PERMANENTLY
METALLURGICALLY—Al-Fin Process
MECHANICALLY—Zollner Lock

EXCLUSIVE ADVANTAGES OF ZOLLNER DESIGNED MECHANICAL LOCK

1. Reverse angle designed top ring section with tapered flutes, dovetail locks in all directions
2. Positive mechanical interlock prevents any movement
3. Reduces weight 25% to 30% with lower inertia stresses
4. Increases surface areas carrying inertia load





ZOLLNER CORPORATION • FORT WAYNE, IND.

ZOLLNER

HEAVY DUTY PISTONS

COMPLETE CO-OPERATION IN ENGINE DEVELOPMENT WITH THE FINEST PISTON FACILITIES

THE 7 HATS OF BORG-WARNER . . . (top) national defense; oil, steel and chemicals; (middle row) agriculture; industrial machinery; aviation; (bottom) automotive industry; home equipment.

From under the 7 Hats of Borg-Warner...

News of advanced auto transmissions now in '62 models!

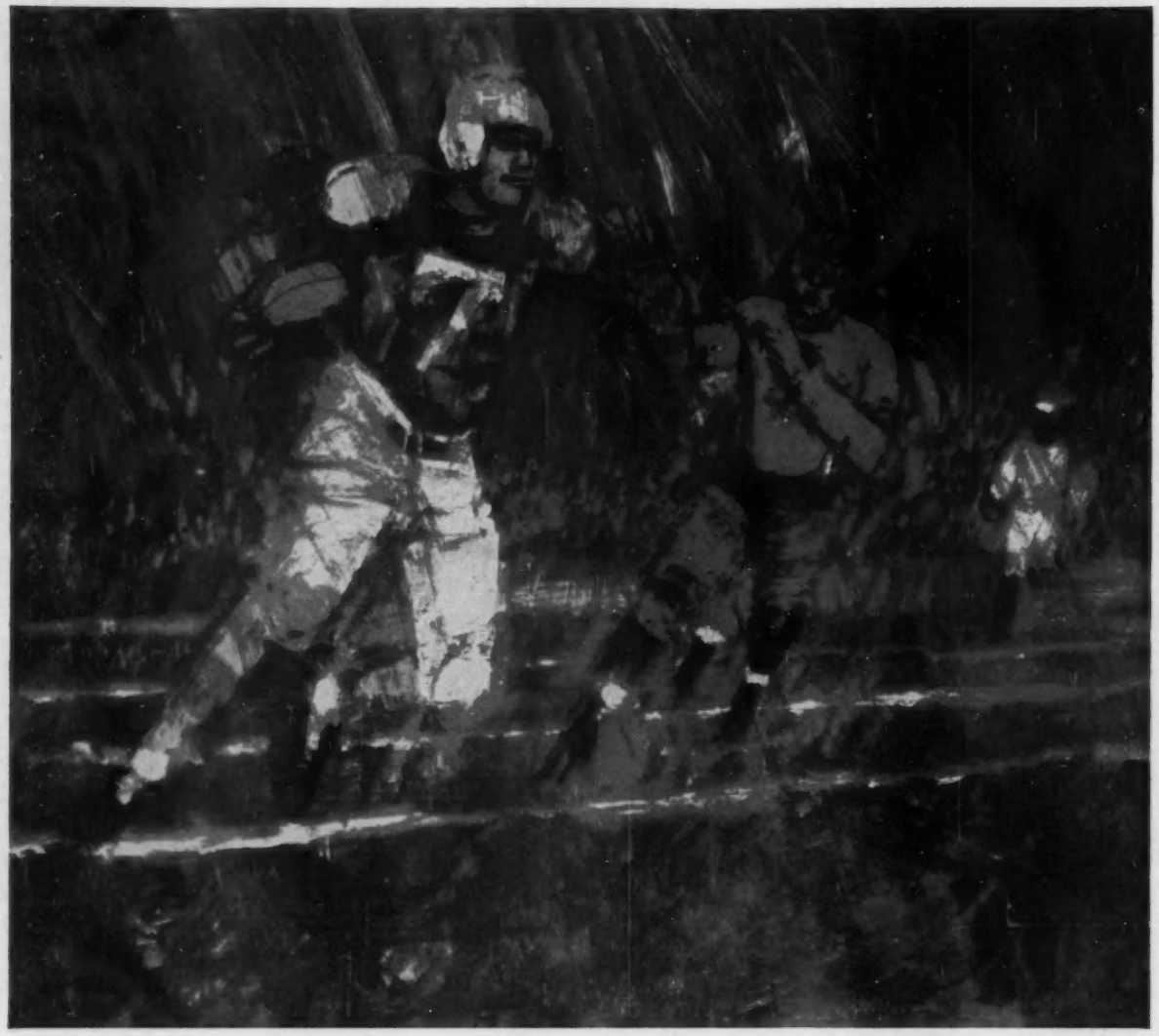
ANNOUNCING: A 3-SPEED AUTOMATIC TRANSMISSION for the new, popular small cars. Lightweight and compact, this is a smaller version of the famous 8-cylinder car transmission from Borg-Warner's Warner Gear Division. Behind this product is a 60-year tradition of engineering and production skill in the manufacture of automotive components. Connected either to lever or push-button gearshift controls, this unit is a versatile newcomer . . . adopted by makers of both American and British cars for 1962.

ANNOUNCING: A "STICK SHIFT" WITHOUT A CLUTCH PEDAL! Now, you can have the economy of a standard transmission and the convenience of automatic—without the footwork! This perfected automatic system from B-W's Borg & Beck Division eliminates the clutch pedal, operates all gears from a "stick shift" mounted by the steering wheel. The secret? A hydraulic system using engine oil pressure. This simplified, trouble-free drive asks little effort or skill from the growing number of "stick shift" fans.

BW **BORG-WARNER**® ...better products through creative research and engineering

Borg-Warner Corporation • 200 South Michigan Avenue • Chicago 4

©1961, B-W Corp.



Remember when..."Dutch" Clark ran 100 yards for a 40-yard TD

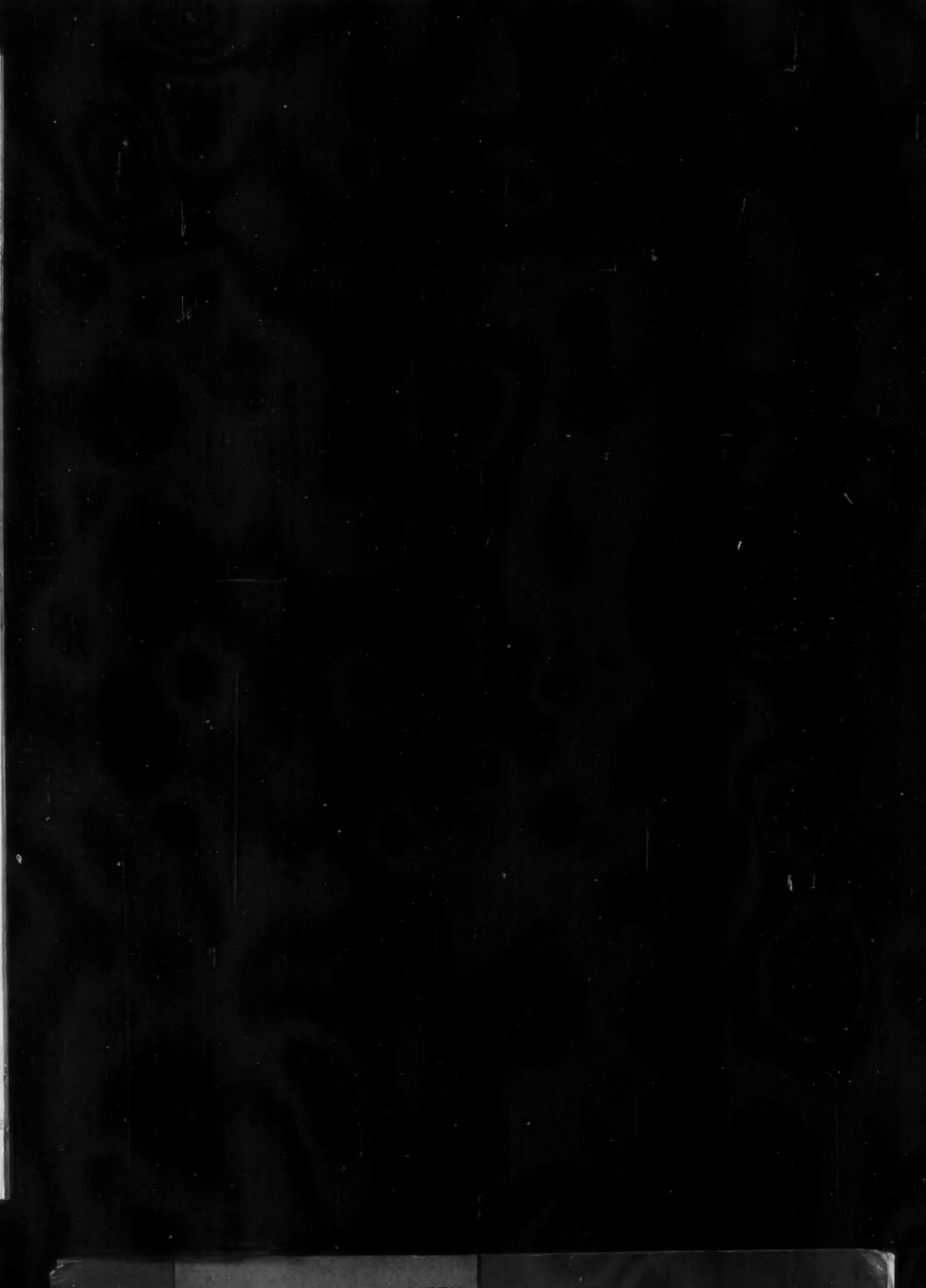
The hot question that cold December 15, 1935 in Detroit was: can the Lions take the world pro football crown from the Giants? In the opening period, Quarterback "Dutch" Clark tore off 40 yards for a TD that observers swore covered more than 100 yards including his cut-backs and swerving. And he led the Lions to their first world title—26-7.

The real pro comes through time after time because of his superior skill and experience.

The same winning qualities work for you when you work with the bearing pros—Timken Company engineers and technicians. They have the most experience in designing, manufacturing and mounting tapered roller bearings. Experience and skill that assure you higher capacity and quality bearings at lower cost . . . to give you reliability, lower assembly and warranty costs. Why settle for less? Call in the pros . . . Timken Company Engineers. The Timken Roller Bearing Company, Canton 6, Ohio. Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

Bearing Pro JIM PILZ says: "Let the pros tackle your tough bearing problems. Call us."

TIMKEN®

tapered roller bearings

Made by the pros of the bearing business